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THE

GARDENER'S AND FARMER'S

REASON WHY

CONTAINING

REASONS FOR THE PRINCIPLES OF SCIENTIFIC CULTIVATION APPLICABLE TO GARDENING AND AGRICULTURE.

BY

THE AUTHOR OF

'THE REASON WHY, GENERAL SCIENCE," "THE REASON WHY, NATURAL HISTORY,' "THE BIBLICAL REASON WHY," "THE HISTORICAL REASON WHY," "THE HOUSEWIFE'S REASON WHY," ETC., ETC.

"Man is the interpreter of Nature, Science the right interpretation."

Dr. Whewell.

"The practical man who adopts this method of solving all useful questions, need entertain no dread of acquiring the reputation of a theorist. He may rest assured that by no other means can he solve a single problem. He must first seek after the 'Why,' and the 'Wherefore' will follow as a matter of course."—*Liebig.*

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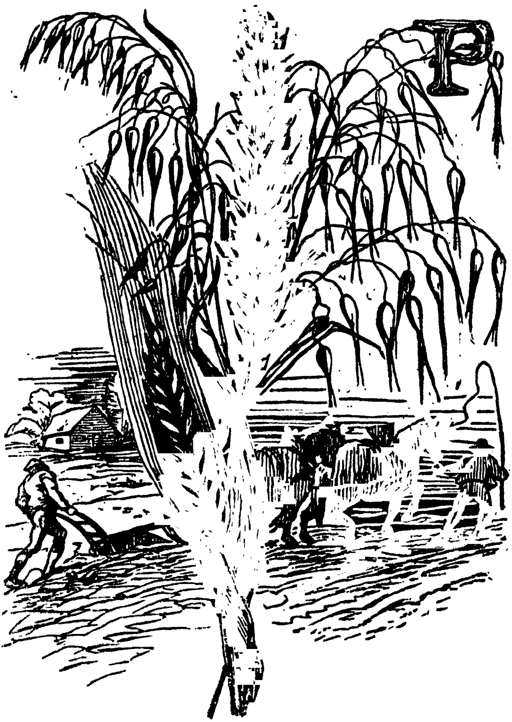
PREFACE.



PROVIDENCE exhibits a purpose in all things; and it is the duty of Man to ascertain what that purpose is. Nothing exists without laws to govern its existence. The higher the organization of a body, the more multiplex are the laws that operate upon its being. Nothing exists that is not, or may not, be made useful to Man; but *the power of using* depends

upon man's comprehension of the laws that govern the existence of material things.

To no class of people can a knowledge of Nature's laws be more interesting or useful than to the FARMER and GARDENER. It is their mission to enrich and beautify the earth. Man cannot *make* a single grain of wheat; but he invokes the aid of Nature. Going forth with the plough, he opens the warm breast of the earth, and scatters the simple seed. A few months roll away, and over that earth, which lately was brown and bare, there wave millions of ears of golden corn. Thus man produces, by limited knowledge of certain laws, a rich store of food, of which, unaided by Nature, he could not create a single grain.

There are, however, different degrees of knowledge. One man may know *that* if he makes a furrow in the soil, and places therein a seed, the seed will grow; and although it may be apparently dead, and be sealed in its tomb by the frost or snow, still the time will come when the leaf will appear above the ground, when the stalk will shoot upward, and the plant continue to grow until it produces fruit.

Another man may know *how* it is that the plant grows. He may know that the seed placed in the soil held within its breast a vital germ, and that heat and moisture called that germ into being. He may know that certain elements in the soil contributed to nourish the germ, and that when the plant put forth its leaves to the air they began to feed upon the atmosphere that played around it in the breezes of spring.

Another man may not only know *how* the plant grows, but *why* it has been endowed with certain organs—*why*

it has a root, *why* a stem, *why* leaves, *why* flowers, *why* seeds; he may know *why* a plant has bark and wood and pith; he may know *why* air and light and moisture are necessary; *why* soils of specific kinds are best suited to particular plants; and *why*, when those plants have fed upon such soils, the soils become impoverished, and can no longer yield to the same plants the nourishment they need; but that, if other plants are placed in the same earth, they will not only thrive, but that during their growth, the soil will become replenished by the elements which had been absorbed by the previous crop.

The knowledge of the first man that we have instanced is such as prevailed some fifty years ago, before SIR HUMPHRY DAVY called attention to the elements of Agricultural Chemistry.

The knowledge of the second man we have instanced, is the knowledge of many of the present day, who are content with general and vague ideas; but who care not to pursue inquiry far, and therefore leave it off at that very point where it becomes interesting and remunerative.

The man who knows the *reason why*—the third we have instanced—is he who has taken advantage of what DAVY and LIEBIG have taught—who has not been contented to allow philosophers to labour and to write in vain—but who looks at Nature through the light of improved philosophy, and sees in every one of her operations something to delight the eye and charm the understanding. To such a man, the duties of life become a pleasing occupation; the business of life is no longer a task. In the words of Shakspeare, "The labour we delight in physics pain."

his name by his course of lectures before the Board of Agriculture, in which he explained the compound organizations of plants, and of soils, and the relations of these to each other; as well as the influence of light, heat, electricity, moisture, and the atmospheric gases, upon the vegetable creation. In later days, the learned LIEBIG has taken up the work commenced by DAVY, and added to the discoveries of the latter many valuable facts which confirm and enrich the theories of the great founder of Agricultural Chemistry.

It is the purpose of this volume to set before the Reader, in the simple form of Question and Answer, many of those important discoveries which come under the denomination of Organic and Inorganic Chemistry, especially in relation to Gardening and Agriculture.

But who is he that pretends to *supply reasons* to men whose lives have been spent in the free air of the country, and from whose feet the brown clod has never yet been shaken? Who is he that, having been fed to maturity by the produce of the plough, ventures now to tell the Agriculturist how he may improve the system of growing wheat, and recompensing the soil for its losses?

A fair question, demanding an explicit answer.

The REASONS presented to the Gardener and Agricul-

The GARDENER'S and FARMER'S REASON WHY is in itself a sort of AGRICULTURAL and HORTICULTURAL SOCIETY, where the leading minds in a given pursuit speak for the good of all.

First, there is SIR HUMPHRY DAVY, who, as long ago as the year 1802, submitted to the Board of Agriculture his views of the influences of chemical laws upon vegetation; at that time chemistry itself was young, and it had been, therefore, impossible to make an earlier application of its principles to the most important of all economical pursuits.

Next, there is Baron Liebig, Professor of Chemistry at Giessen, whose enlarged views of Agricultural Chemistry have been the theme of discussion and experiment since the year 1840, and whose opinions, carefully analyzed, are presented in this work, as expressed by himself so recently as last year (1859), after reviewing the previous twenty years' experience.

Then there is MR. LAWES, of Rothamstead Park, whose papers on Agricultural Chemistry, in the *Royal Agricultural Society's Journal*, have created so great an interest, and

whose experiments, conducted upon his own farm, under his immediate superintendence, have proved of great practical value. *Although* MR. LAWES *differs in his conclusions from the principles laid down by* LIEBIG, *his theory points equally to the importance of applying scientific principles to the cultivation of plants ; and* LIEBIG *aspires to indicate the* ONLY TRUE *principles.*

Among many other Authorities whose views and experience are given in this volume, are DR. VOELCKER, Professor of Chemistry to the Royal Agricultural College, Cirencester ; DR. CHARLES SPREGNEL, Professor of Agriculture in the Caroline College of Brunswick ; DR. DAUBENY, Professor of Rural Economy in the University of Oxford ; J. F. W. JOHNSTON, Esq., F.R.S., Author of "Lectures on Agriculture in Relation to Chemistry and Geology ;" DR. S. L. DANA, of Lowell, U.S., Author of "A Muck Manual for Farmers ;" J. T. WAY, Esq., Consulting Chemist to the Royal Agricultural Society ; J. C. NESBIT, Esq., Principal of the Agricultural and Chemical College, Kensington ; J. A. NASH, Esq., Instructor of Agriculture in Amherst College, and Member of the Massachusetts Board of Agriculture ; A. D. THÄER, of Celle, in Germany, an eminent agriculturist and author of important works upon Husbandry ; HENRY STEPHENS, Esq., F.R.S.E., Author of "The Book of the Farm," and "The Book of the Garden;" J. C. MORTON, Esq., Author of "A Cyclopædia of Agriculture, Practical and Scientific," and Editor of "The Agricultural Gazette ;" C. W. JOHNSON, Esq., Author of the "Farmer's Cyclopædia ;" PH. PUSEY, Esq., late President of the Royal Agricultural Society ; LORD ASHBURTON, President of the Royal Agricultural Society; A. T. KNIGHT, Esq., late President of the Royal Horti-

cultural Society; SIR JOHN SINCLAIR, the great promoter of the Board of Agriculture, and of numerous practical improvements; together with many others, including farmers of the "old school," whose names will be found appended as notes to their various opinions, and statements of fact.

With such an array of Authorities as these, it matters little who the individual may be that has brought into one focus so large an amount of divergent theory and experience upon the important subjects of Agriculture and Gardening.

There is only one point, in his own labours, to which the Author of this volume begs to call especial attention. When, in the company of a keeper, he has walked over farm lands in pursuit of game, the practised eye of the latter has been able, in an instant, to recognise the run of a rabbit or hare, or the trail of a pheasant, as indicated by the dog in pursuit; when called upon to "look out," the Author has lost many a shot by not having placed reliance in the premonitions of a practised observer. "There she sits!" said the Keeper one day; pointing to something at a distance, upon a fallow field. But the untutored eye of a Novice could see nothing other than clods of earth, where the Countryman plainly descried Puss, serenely squatting upon her form. Doubting the intimation, the Novice sauntered onward, until Puss, springing from close by his feet, started off with a speed accelerated by the report of a shot far in her rear, which raised only a cloud of dust from the scattered mould, while the Countryman doffed his hat, and broke cover with his fingers, to ease his outraged senses. Let it be understood, however, that in latter years this fault has been amended, and that the Novice has profited by experience!

This illustration is intended to enforce a matter in point: *in the setting forth of ideas, as in the marking down of game, there is a certain degree of sagacity not easily acquired.* The Author is, in this instance, the Keeper; he has to take the Farmer over the pages of this book, and *to point out where anything lies which, being brought to the bag of the understanding, will crown the pursuit.* The "run" of any particular idea, which the Farmer is required to follow, is here indicated by *italic letters;* when the Reader sees these, let him *fix his attention to their meaning,* follow them closely, and when he comes upon SMALL CAPITALS, he is *close upon the game,* and must LOOK OUT, or, like the Author with the hare, *he will, through inattention, get only dust in his eyes, where he might have brought something valuable to his bag.*

It should be stated here, that the treatment of the *Anatomy and Physiology of Plants,* with explanations of the special uses of peculiar properties and structures, has been reserved for the BOTANICAL AND HORTICULTURAL REASON WHY, which will follow this in the Series, and be an admirable companion to the present volume.

London, 1860.

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The Numbers refer to the Paragraphs.

'So with superior boon may your rich soil,
Exuberant, Nature's better blessings pour
O'er every land, the naked nations clothe,
And be the exhaustless granary of a world."—THOMSON.

THE

GARDENER'S AND FARMER'S REASON WHY.

☞ *In a work designed to instruct the Cultivators of the Soil (whose present practical knowledge must not be despised), and who cannot test new theories without expenditure and risk of labour and capital,—it has been deemed advisable to* quote the authority for every Theory, Opinion, or Fact.

I.

CHEMISTRY OF VEGETATION; ELEMENTS OF VEGETABLE SUBSTANCES; VITAL PROCESSES; SOILS; MANURES.

1. *Why do plants grow?* *

Because they possess an *organization* which enables them to incorporate with their own systems certain *elements* by which they are surrounded. Air, water, and earth are obviously elements of nutrition to plants. But "air," "water," and "earth," are only *general terms;* the air consists of *gases;* water of *gases;* and earth of various *chemicals,* such as *carbon, oxygen, hydrogen, nitrogen, lime,*

* The *reason* assigned must always bear relation to the *principle* which the question seeks to illustrate. Thus, if we were demonstrating the power and goodness of the Creator, we should say that plants grow because He has ordained them to beautify the earth, to purify the air, and to serve as food for man and the inferior animals. But, at the point at which we commence, *this primary fact is assumed,* and we proceed to show *in detail,* according to our best knowledge, *the means by which the Creator works in organic nature.*

"Clear the brown path to meet the coulter's gleam!
Lo! on he comes, behind his smoking team,
With toil's bright dew-drops on his sun-burnt brow,
The lord of earth—the Hero of the Plough!

sulphur, *silica*, &c. To comprehend, therefore, "how plants grow," we must *examine their organization, and study the nature of those substances which constitute their food.*

2. **Vegetables may be truly said** to be *living systems*, in this sense, that they possess the means of converting the *elements of common matter* into organized structures, both by *assimilation* and *reproduction*; but we must not suffer ourselves to be deluded by the very extensive application of the word *life* to conceive, in the *life of plants*, any power similar to that producing the *life of animals*. In calling forth the vegetable functions, common physical agents alone seem to operate; but in the animal system those agents are made *subservient to a superior principle.*

3. *Agricultural chemistry* has for its objects *all the changes in the arrangements of matter connected with the growth and nourishment of plants; the comparative values of their produce as food; the constitution of soils; the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation.* Enquiries of such a nature cannot but be interesting and important both to the theoretical agriculturist, and to the practical farmer. To the first, they are necessary in supplying most of the fundamental principles on which the theory depends. To the second, they are useful in affording simple and easy experiments for directing his labours, and for enabling him to pursue a certain and systematic plan of improvement.*

4. *The presence of a growing plant, of the root of a seed, where* LIFE *is, impresses on the soil, both on the organic and inorganic elements,* POWER TO ENTER INTO NEW ARRANGEMENTS. *The soil, then, is not external to the plants; so far as life is concerned,* IT IS AS MUCH INTERNAL AS IF THE PLANT HAD A MOUTH AND A STOMACH, THROUGH, AND INTO WHICH THE SOIL MIGHT BE FED.†

5. *What are the principal simple chemicals that influence the growth of vegetables?*

They are *carbon*, *oxygen*, *hydrogen*, and *nitrogen*. The

* Sir Humphry Davy's "Agricultural Chemistry."
† T. L. Dana's "Muck Book."

"First in the field before the reddening sun,
Last in the shadow when the day is done.
Line after line along the burning sod,
Marks the broad acres where his feet have trod;

other substances of plants, it will be seen, are compounded of *two or more* simple elements.

6. There is no reason why the agriculturist should not be as familiar with the names and properties of *carbon, oxygen, hydrogen,* and *nitrogen,* as he is with those of *coals, lime,* and *salt.* Being familiar with the primary elements, he will the more readily comprehend the *functions of vegetables,* and the *conditions favourable to their development.* Who, without any formal scientific instruction, is not familiar with the names of *iron, sulphur, potash, soda,* and *lime*? No one; for they are of every-day occurrence. And, who does not know that *coal* is *carbon*? And who has never heard that *oxygen* and *nitrogen* form the air we breathe; or that water is composed of *oxygen* and *hydrogen*?

7. With *alumina* or *alum* all are familiar. *Silex* or *silica* is but the name of portions of hard stones. Most persons, too, are no strangers to what is called *ammonia,* which is a *combination of nitrogen and hydrogen,* is sometimes called *sal volatile,* and is what gives the sharp smell in the *smelling-bottle,* or the *manure heap.* IT IS THE AMMONIA IN MANURE WHICH IS SO EFFICACIOUS IN AGRICULTURE. And, if the reader is less familiar with the name of *chlorine,* it is easy to give him some hints of it. This is the substance used in bleaching cotton goods, and on opening them the smell is very pungent for a long time. And what is still more in point, *chlorine united with soda makes our common salt*; or, *if united with ammonia,* the product is what is called in the shops *sal ammoniac.* The circumstance that chlorine is a constituent of common salt, is in itself sufficient to give it an interest in impressing it on the memory of every individual.

8. *Chlorine* is important also from being used to disinfect the air when impregnated with foul vapours, as in the case of cholera and other diseases. Here, then, is nearly the whole catalogue of these obnoxious terms, save *manganese,* which is simply a dark-coloured metal, used in the manufacture of glass as well as in agriculture.*

9. *What is "an element?"*

A body that is constituted of *one* kind of matter only, is

* Rev. J. L. Blake, D.D.

"Still where he treads the stubborn clods divide,
The smooth fresh furrows open deep and wide;
Matted and dense the tangled turf upheaves,
Mellowed and dark the ridgy corn-field cleaves;

called an *element*. One that is composed of *two* elements, is a *compound*.

10. If a body consists of three elements, it is called a *ternary* compound; if of four, a *quaternary* compound. *Binary* implies two-fold; *ternary*, three-fold, and *quaternary*, four-fold.*

11. Iron, being composed of one kind of matter, is an *element;* the *rust* of iron is a *compound*, being formed of *oxygen* and *iron*. Put a little drop of water upon a piece of bright iron; after a short time, wipe it away, and there will remain a spot of rust. The oxygen of the water, or a part of it, will have combined with portions of the iron, and formed an oxide of iron, a binary compound, or compound of two elements. Water is composed of two elements; Epsom salts of three; alum of four, and so on.*

12. We must distinguish between a *compound* and a *mixture*. When two substances combine of their own accord, as if self-moved, the result is a *compound*. If they are only put together by mechanical force, it is a *mixture*. In the first case, the properties of the ingredients are entirely changed; in the last, they remain unaltered. Thus, if you bring chlorine and sodium together, a substance totally unlike either is produced—from two virulent poisons, a wholesome condiment, *common salt*, is formed: this is a *compound*. But if you put water with milk, no new substance is formed—the properties of the ingredients remain unaltered; they are water and milk still, and nothing more: this is a mere *mixture*.

13. *What is carbon?*

Carbon is a chemical element, abounding in nature, the

* J. A. Nash's "Progressive Farmer."

"Up the steep hill-side, where the labouring train
Marks the wide track that scores the level plain;
Through the moist valley, clogged with oozing clay,
The patient-convoy breaks its destined way;

most familiar form of which is *charcoal.* How large a proportion of vegetables consists of this substance may be ascertained by charring a piece of wood.

14. When wood is burnt with a smothered flame, the volatile parts are driven off by heat, and there remains behind a substance exhibiting the exact form, and even the several layers of the original wood. This process is denominated *charring*, and the substance obtained *charcoal.* As it is the woody fibre alone which resists the action of heat, while the other parts of the substance are dispersed, it is plain that charcoal must be the residuum of woody fibre, and that the quantity of the one, must depend upon the quantity of the other, if they are not to be considered actually the same. Charcoal may be obtained from almost all the parts of plants, whether solid or fluid.*

15. *The properties of charcoal* are, insolubility in water, of which however, it absorbs a portion when newly made, as also of atmospheric air. It is incapable of putrefaction. It is not altered by the most violent heat that can be applied, *if all air and moisture are excluded.* But, burnt in air, it combines with the oxygen of the atmosphere, forming *carbonic acid gas;*† and it is important to bear in mind that *this gas is one of the natural constituents of the atmosphere, by which plants are surrounded.*

16. *What is oxygen?*

Oxygen is an element known *only* in the state of a *gas*, or in an *air-like condition.* It is void of colour, taste, and smell, and therefore cannot be distinguished from common air. It exists in the *atmosphere*, in *water*, and in *minerals*, and is necessary to the life of *both plants and animals.*

17. *What is hydrogen?*

Hydrogen is also known to us *only* in the state of *gas*, and when perfectly pure is scarcely distinguishable from common air, being without colour or taste, and possessing but little

* Loudon's Encyclopædia of Agriculture. † D. J. Browne.

"At every turn the loosening chains resound,
The swinging plough-share glistens in the ground,
Till the wide field one billowy waste appears,
And sinewy hands unbind the panting steers.

smell. Although we can easily obtain it as a gas, it does not usually exist as such, but it combines with ALL *animal* and *vegetable substances*, abounds in *water*, and is found largely in *coal*, but is not found in any other of the large mineral masses.

18. *What is nitrogen?*

Nitrogen, also, is known to us only in the form of *gas*. It is without colour, taste, or smell. It is found most abundantly in the *atmosphere;* and forms a part of *many animal*, and *some vegetable* substances.

19. Such are the simple elementary bodies of which the organic, or destructible part, of vegetable substances is formed. With ONE EXCEPTION, they are *known to us only in the form of gases;* and yet, *out of these gases much of the solid parts of animals and of plants are made up.* When ALONE, at the ordinary temperature of the atmosphere, they form *invisible kinds of air;* when UNITED, *they constitute those various forms of vegetable matter which it is the aim and end of the art of culture to raise with rapidity, with certainty, and in abundance.* How difficult to understand are the intricate processes by which nature works up those rare materials into her many beautiful productions; *yet how interesting it must be to know her ways—how useful even partially to find them out.*

20. *Whence do plants obtain carbon?*

Carbon exists *in the atmosphere*, in the form of *carbonic acid gas;* and in the *soil*, in the form of *humus*, or decayed vegetable matter, commonly called *vegetable mould.*

21. A plant obtains its carbon CHIEFLY from the *air*, but PARTLY from the "vegetable mould" of the *soil.*

22. Fitted by nature to draw their sustenance, now from the *earth*, now from the *air*, and now from *both*, according as they can most readily obtain it, plants are capable of living—though rarely a robust

"These are the hands whose sturdy labour brings
The peasant's food, the golden pomp of kings;
This is the page whose letters shall be seen
Changed by the sun to words of living green;

life—*at the expense of either*. The *proportion* of food which they actually derive from each source, will depend upon many circumstances; on the nature of the plant itself; on the period of its growth; on the soil in which it is planted; on the abundance of food presented to either extremity; on the warmth and moisture of the climate; on the duration and intensity of the sunshine, and other circumstances of a similar kind; so that the only general law seems to be, that, like animals, plants have the power of *adapting themselves, to a certain extent, to the conditions in which they are placed;* and of supporting life by the aid of such sustenance as may be within their reach.*

23. But it may be affirmed with positive certainty that the carbon of plants is not derived *directly* from the *assimilation* of vegetable mould, or humus. The latter acts in the same manner in a soil permeable to air *as in the air itself;* it is a continued source of *carbonic acid gas,* which it emits very slowly. An atmosphere of this gas surrounds every particle of decaying humus. *The cultivation of land, by tilling and loosening the soil, causes a free and unobstructed access of air.* An atmosphere of carbonic acid is therefore contained in every fertile soil, and is the first and most important food for the young plants growing upon it. *The carbonic acid gas which surrounds the decaying humus, is absorbed and taken away by the fine fibres of the roots,* and by the roots themselves; this is replaced by atmospheric air, which renews the process of decay, and forms fresh carbonic acid gas. A plant at this time receives its food both by the *roots,* and by the *leaves.*†

24. The result of numerous experiments establishes, beyond all doubt, the *decomposition of carbonic acid gas by plants,* and the *expiration of oxygen.* Branches and leaves of various plants were placed under air-tight glasses, in an atmosphere charged with about five or six per cent. of *carbonic acid.* In one case, the jar contained about 600 cubic inches of air, and the plant experimented upon was the common *lilac.* The first day no great alteration in the air was detected, but on the second day, by eight in the evening, the *oxygen* had risen to 26·5 per cent. In the morning, it had sunk to 26, but, by two p.m., it had again risen to no less than 29·75, and by sunset it had reached 30 per cent.‡

* Johnston's "Lectures on Agricultural Chemistry and Geology."
† Liebig. ‡ Dr. Daubeny "On the Action of Light upon Plants."

"This is the scholar whose immortal pen
Spells the first lesson hunger taught to men;
These are the lines, O Heaven-commanded toil,
That fill thy deed—the charter of the soil!"—DR. HOLMES.

25. *Whence do plants obtain oxygen?*

The *water* which plants imbibe consists in great part of *oxygen;* the *atmosphere* which surrounds them contains twenty-one per cent. of its bulk of *oxygen; carbonic acid gas,* from which they derive their carbon, consists of seventy-two per cent. by weight of *oxygen;* and it enters more or less into the composition of *all organic and mineral substances.*

26. The amount of *oxygen* supplied to plants is so large, that it always exists in *excess of their wants;* and one of their chief functions is to *set oxygen free for the use of animals,* in the function of *breathing.* Ponds and ditches, the bottoms of which are covered with growing plants, often freeze upon their surface in winter, so that the water is completely excluded from the atmosphere by a clear stratum of ice; under such circumstances small bubbles of gas are observed to escape continually during the day from points of the leaves and twigs. These bubbles are seen most distinctly when the rays of the sun fall upon the ice; they are very small at first, but collect under the ice and form larger bubbles. They consist of pure oxygen gas. Neither during the night, nor during the day when the sun does not shine, are they observed to diminish in quantity. The source of the *oxygen* is the *decomposition* of *carbonic acid gas* by the plants beneath the water. They have absorbed the *carbon,* and appropriated it to their own use, and set the oxygen (or at least a part of it) free.*

27. *Whence do plants obtain hydrogen?*

Most vegetable structures contain hydrogen in the form of *water,* which can be separated as such, and replaced by other bodies; but *the* hydrogen *essential to their constitution* cannot possibly exist *in the state of water.* All the *hydrogen* necessary for the formation of an organic compound is supplied to a plant by the *decomposition of water.* The process, in its most simple form, consists in the *extraction of hydrogen from water,* in consequence of which, either all or a part of the *oxygen,* combined with the *hydrogen* in water, is exhaled.*

* Liebig.

"To study God, God's student man was made,
To read him as in nature's text conveyed;
And save his miracles, each little flower,
And lesser fly, shows his familiar power."—SIR W. DAVENANT.

28. This extraction of *hydrogen* from *water* may be effected by the *leaves*, *tissues*, and *roots* of plants. In the form of vapour, water pervades the atmosphere, and plays among the leaves; while in the liquid state it is diffused through the soil, and is unceasingly drunk in by the roots. In the interior of plants, at least during their growth, this water is continually undergoing decomposition, and it is unquestionably the chief source of the hydrogen which enters into the constitution of their several parts. Though there are undoubtedly *several other* forms of combination in which *hydrogen* may enter into their circulation, in uncertain quantity, yet all-pervading *water* is the *main and constant source* from which the *hydrogen* of vegetable substances is derived.*

29. *Whence do plants obtain nitrogen?*

Nitrogen forms only a *small part* of plants; but it is never entirely absent. It is found in the form of *vegetable albumen* and *gluten*, and in the *seeds* and various *juices*. There are, therefore, *nitrogenised* products of plants, and *non-nitrogenised*.

30. The chief source of the *nitrogen of plants* is supposed to be *ammonia*, which is the *nitrogen of putrefied animals diffused throughout the atmosphere in the state of a gas.*

31. *Ammonia*, in its gaseous form, is of extreme solubility in water. It cannot, therefore, remain long suspended in the atmosphere, as *every shower of rain must effect its condensation*, and convey it to the surface of the earth. Thus, rain-water at all times contains ammonia, though not always in equal quantity. It must contain more in summer than in spring or in winter, *because the intervals of time between the showers in summer and winter are greater*; and, when several wet days occur, the rain of the first must contain more of it than that of the second. The rain of a *thunder-storm*, after a long-protracted drought, for this reason should contain the greatest quantity conveyed to the earth at any one time. It is worthy of observation that the *ammonia* contained in *rain* and *snow water* possesses an offensive smell of perspiration and putrefying matter; a fact which leaves no doubt respecting its origin.† This

* Johnston. †

"The soil must be renew'd which often washed,
Loses its treasure of salubrious salts,
And disappoints the roots."—COWPER.

also accounts for the slightly pungent smell of rain water, and especially of vessels in which it has long remained.

31*. The *nitrogen* which enters into plants has been thought to remain for the greater part within them, and to be gathered in the crop in the form of muscle-producing ingredients. But recent experiments, in the United States of America, by Professor Draper, have shown that plants are *constantly giving off nitrogen from their leaves in large quantities into the air;* and it appears probable, that of the nitrogen which enters their roots only a *small proportion remains* at last in the full-grown plant, compared with what is thus discharged into the atmosphere.*

32. *Why is it supposed that plants derive their nitrogen from ammonia?*

Because ammonia consists of *a loose conbination of nitrogen with hydrogen,* and the compound is extremely *soluble in water* and acids. The facility with which it is resolved into various and opposite forms, seems exactly calculated to enter into the vegetable organization, and to supply the nitrogen which it requires.†

33. *Why is there such a great variety of vegetable products?*

Because the simple elements of which plants are composed *combine in various proportions,* forming *secretions* of different and even opposite properties. Thus :—

Starch consists of

	Per cent.
Carbon	44·0
Hydrogen	6·2
Oxygen	49·8

Gum consists of

	Per cent.
Carbon	45·10
Hydrogen	6·10
Oxygen	48·80

* Johnston. † Dr. Daubeny.

"The perfumed flowers, with leaflets brighte,
The verdaunt grasse, the wavinge corne,
Doe all returne to that foul plighte
From whence their own sweet life was borne.

Cane sugar consists of

	Per cent.
Carbon	44·92
Hydrogen	6·11
Oygen	48·97

Gluten and *vegetable albumen* consist of

	Per cent.
Carbon	54·76
Hydrogen	7·06
Oxygen	20·06
Nitrogen	18·12

34. The following Table * shows the proportions of the *simple elements, water,* and *inorganic substances,* in various plants :—

ONE HUNDRED PARTS CONTAIN :—

Name of Plant.	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Water.	Inorganic Matter.
Clover-hay	37·3	3·8	30·0	2·0	21·0	5·9
Mangel-wurzel . . .	5·2	0·8	5·2	0·2	87·8	0·8
Oats	40·1	5·1	29·1	1·8	20·8	3·1
Oat-straw	35·7	3·9	27·8	0·3	28·7	3·6
Peas	42·5	5·7	36·6	3·8	8·6	2·8
Pea-straw	40·3	4·5	31·4	2·0	11·8	10·1
Potatoes	10·6	1·4	10·8	0·3	75·9	1·0
Rye	39·1	4·8	36·0	1·5	16·6	2·0
Rye-straw	40·6	4·6	33·0	0·2	18·7	2·9
Turnips	3·2	0·4	3·2	0·1	92·5	0·6
Wheat	39·4	5·0	37·1	3·0	14·5	2·0
Wheat-straw	35·8	3·9	28·8	0·3	26·0	5·2
Wood	50·0	5·0	42·0	—	—	3·0

* Cameron's "Chemistry of Agriculture.'

"The essence which within them lurkes
Doth helpe another race to be;
Soe God in endless circles workes,
And thus ordains his alchemie."—OLD MS.

35. All *vegetable acids* contain *carbon*, *oxygen*, and *hydrogen;* and *prussic acid* contains also a portion of *nitrogen*. *Gallic acid* contains the largest proportion of *carbon;* and *oxalic acid* the largest proportion of *oxygen*.

36. *What are the organic constituents of plants?*

The *organic* constituents of plants are those which are commonly known as "vegetable substances," or "vegetable productions"—*starch, gum, sugar, gluten, albumen, &c.* They are the product of plants *endowed with life*, and *cannot be produced without the operation of life*. This mysterious power *influences the elements, and re-combines them in various forms*. They are the products of *living organs*, and therefore termed *organic*. While they are being formed, the chemical laws affecting them are modified by the *living principle;* when that principle ceases—though in some cases it may be retained for a long time, as in the case of a seed—when the plant or seed *dies*—the substances are operated upon by chemical laws, and undergo various changes. Organic substances are *for the most part* compounded of *four simple elements;* NEVER less than *three*. The elements which enter so invariably into these organic compounds are called *organic elements*, as *carbon*, *oxygen*, *hydrogen* and *nitrogen*, and the various bodies *compounded of these* are called *organic substances*.

37. The old notion—that which prevailed at the close of the sixteenth century—was, that there existed in animals, plants, and soils, one universal, vitalising, and fertilising principle, namely, *salt;* and this miserable and vague theory was upheld by the most learned men of that age. It was thus expressed by the early writers upon agriculture: —"Salt whiteneth all thinges, it preserveth all thinges, it hardeneth all thinges, it giveth savour to all thinges, it is a masticke that gleweth all thinges together, it gathereth and knitteth all minerall matters, and of

> "Adieu, the city's ceaseless hum,
> The haunts of sensual life, adieu;
> Green fields and silent glens, we come
> To spend this bright spring day with you."—J. ALDRICH.

manie thousand peeces it maketh one masse. This salt giveth sound to all thinges, and without the salt no metall will wring his shirle voyce. Salt maketh men merrie, it whiteneth the flesh, and it giveth beauty to all reasonable creatures, it entertayneth that love and amitie which is between the male and female, through the great vigour and stirring uppe which it provoketh in the engendering members; it helpeth procreation, it giveth unto creatures their voyce, as also unto metalles. And it is salt that maketh all seedes to flourish and growe, and although the number of men is verie small, which can give any true reason whie dungue should doe anie good in arable groundes, but are ledde thereto more by custome than anie philosophicall reason, neverthcless it is appaurent that no dungue, which is layde upon barraine groundes, could anie way enrich the same, if it were not for the salt which the straw and hay left behinde them by their putrefaction." *

38. *What are the inorganic constituents of plants?*

They consist of *silica*, *alumina*, *potash*, *soda*, *lime*, *magnesia*, *phosphate of lime*, *common salt*, *sulphuric acid* in the form of *sulphate of lime*, and some other *sulphates*, &c. Many of the inorganic substances vary according to the soil in which the plants grow, but *a certain number of them* are indispensable to their development. All substances in *solution* in a soil are absorbed by the roots of plants, exactly *as a sponge imbibes a liquid*, and all that it contains, *without selection.*

39. But there are alkaline and earthy phosphates that form *invariable constituents* of all kinds of *grasses*, of *beans*, *peas*, and *lentils*.†

40. The *inorganic* substances are generally combinations of TWO *elementary bodies.* They are wholly mineral; they are the products of the chemical action of the metallic or non-metallic elements of rocks. *They existed before plants or animals.*

* Philp's History of Progress: Art. "Progress of Agriculture." † Liebig.

"The work is done, no more to man is given,
The grateful farmer trusts the rest to Heaven;
Yet oft with anxious heart he looks around
And marks the first green blade that breaks the ground."—BLOOMFIELD.

41. When vegetable substances are burnt, there remains behind a portion commonly called the *ash*, and this constitutes the *inorganic* portion of plants. The proportion of *ash* to the bulk of vegetable substance is very small, varying from *one* to *twelve per cent*. The smallness of these proportions has led some persons to the opinion that the mineral or inorganic constituents of plants are merely *accidentally* present, and are not *necessary* to their existence. This may be true as far as regards those matters which are *not always found in plants of the same kind;* but when they are *invariably present*, the smallness of their quantity *does not indicate their inutility*. The *phosphate of lime* existing in the *animal* body does not amount to the *fifth part* of its weight: *yet no one doubts that this salt is necessary for the formation of bones.**

42. It has been generally supposed that these materials act in the vegetable economy in the same manner as *condiments* or *stimulants* in the animal economy; and thus they render the common food more nutritive. *It* seems, however, a much more probable idea that they are *actually* a part of the TRUE FOOD of *plants*, and that they supply that *kind of matter to the vegetable fibre* which is *analogous to the bony matter in animal structures.* Thus, those plants which are most benefited by the application of *gypsum* are those which always afford them upon analysis. *Clover*, and most of the *artificial grasses* contain them but they exist in very minute quantity only in *barley*, *wheat*, and *turnips*.†

43. A knowledge of these inorganic constituents, and of the nature and chemical composition of soils, must necessarily regulate the practice of every branch of agriculture. Attention must be paid to the *kind and quality of the crop*, and the nature and *chemical composition of the soil* in which it grows. Are any of the *salts of iron* present? They may be decomposed by *lime*. Is there an excess of *silicious sand?* The system of improvement must depend on the application of *clay* and *calcareous matter*. Is there a defect of *calcareous matter?* The remedy is obvious. Is an excess of *vegetable matter* indicated? It may be removed by *liming*, *paring*, and *burning*. Is there a deficiency of *vegetable matter?* It is to be supplied by *manure*.†

* De Saussure. † Sir H. Davy.

"At the old farm gate
A merry group in high expectance wait—
The happy farmer, and the welcome guest,
The city cousin—very nicely dressed!"—BATCHELDER.

44. *What is silica?*

It is a substance which occurs in nature more frequently and abundantly than any of the other earths. All *hard stones* which give out sparks when struck by steel; the enormous masses of *granite;* together with the vast accumulations of *sand* in deserts and in plains, are mainly composed of *silica*; and there are few stones that do not contain more or less of this substance.

45. There is *scarcely a single plant that does not contain it.* Grasses, in particular, contain *large quantities* of it; and it forms the grass-like coating on the *straw of wheat.*

46. *What is alumina?*

Alumina is the earth which, next to *silica*, is found most frequently, and in the greatest abundance in our soils. *Clay*, into the composition of which *alumina* always enters, exists in a greater or less degree in every soil, and is also found in extensive strata beneath the surface of the earth. Moreover, *alumina* forms a constituent part of most *stones*, and in some it is the principal ingredient. *A small quantity of it is found in the ashes of most vegetables.*

47. This earth is of great importance to the agriculturist; in order to enable him duly to appreciate the influence of *clay* upon his fields, and the improvement or deterioration of the soil which it occasions. *Alumina* appears to have a greater affinity for *water* than any of the other elementary earths. It has a very powerful affinity for the other earths, and in certain cases enters readily into combination with them. It has a very great tendency *to unite with silica.* It is in consequence of this affinity that *silica* is so often combined with *alumina* in forming the compound called *clay. Lime* also has a strong affinity for *alumina*, which explains the great fusibility of these earths when mixed.*

* Thaer's "Principles of Agriculture."

"'Tis merry, merry in the spring,
And merry in the summer time,
And merry when the great winds sing.

48. *Alumina* exercises only an *indirect* influence on vegetation, by its power of *attracting and retaining water* and *ammonia*. It is itself *very rarely* found in the ashes of plants.*

49. *What is potash?*

Potash is procured from the *ashes of plants*, by burning and other processes. The plants which yield the greatest proportion of *potash* are *wormwood* and *furmitory*. Refined potash is called *pearlash*, and is, in that state, an impure *carbonate of potash*, or *potash* with *carbon*.

50. *Wood ashes* are certainly a valuable manure, and are peculiarly well adapted for *gravelly soils* and *loams*. This remark applies to the ashes of almost every description of vegetable *land weeds*, *grasses*, *peat*, and *sea weeds*.

51. *What is soda?*

Soda is obtained chiefly from two sources, *the burning of marine vegetables*, such as common sea-weed, which furnishes the alkali called *kelp*; and the *decomposition of common salt*.

52. A material purpose which these carbonates (*carbonate of potash* and *carbonate of soda*) are supposed to serve, is that of *combining with, and rendering soluble the vegetable matter of the soil*, so as to bring it into a state in which it may be *readily taken up by the roots*. They may in this case be said to *prepare the food of plants*. This mode of action can be exercised in its fullest extent only *where vegetable matter abounds* in the soil. They are, therefore, most useful where vegetable matter is plentiful, and ought to be employed more sparingly, and with some degree of caution, where such organic matter is deficient. Another mode in which these substances act, more obscurely perhaps, though not less certainly, is by disposing the organic matters contained in the sap of the plant, to form such new combinations as may be required for the production of the several parts of the living vegetable.†

* Liebig. † Johnston's Lectures.

'Through Autumn's woodlands brown—
When from the tall trees scatter down
Ripe acorns fringed with rime.

53. *What is lime?*

Lime is one of the most abundant substances in nature; it forms whole mountain chains, and together with other earths and metallic compounds, constitutes a great number of minerals. *It forms a constituent part of all vegetables*; and in animals it forms the principal ingredient of shells and bones. In its chemical constitution, *lime* is composed of a peculiar metal called *calcium*, and *oxygen*.

54. *What is magnesia?*

Magnesia is an earth less abundant than lime. It is never met with pure, but always *mixed with other earths*, and *combined with acids*. Several *minerals* contain proportions of it; *springs*, *rivers*, the *sea*, and *salt* water also contain it. *The ashes of most vegetables contain it*; it sometimes forms a very considerable constituent part of the layer of *vegetable mould*, and of that *marl* which is best adapted for the purpose of *manure*. The *bran of flour* contains a large quantity of *ammoniacal phosphate of magnesia*. This salt forms large crystalline concretions, often amounting to several pounds in weight, in the *cæcum* of horses belonging to millers; and when *ammonia* is mixed with beer, the same salt separates as a white precipitate.

55. Liebig makes an important division of plants, according to their proportions of these *inorganic substances*. Thus: POTASH PLANTS he defines to be those the ashes of which contain more than half their weight of *soluble alkaline salts*. LIME PLANTS, and SILICA PLANTS, are those in which *lime* and *silica* respectively predominate. The ingredients thus indicated, are those which form the distinguishing characteristics of the plants which require an abundant supply of them for their growth.

56. The *potash plants* include the *beet*, *mangel-wurzel*, *turnip*, *maize*, &c. The *lime plants* comprehend *clover*, *beans*, *peas*, *tobacco*, &c.

"And in the winter wild and cold,
'Tis merry, merry too;
Then man and boy are blithe and bold;

The *silica plants* include *wheat, oats, rye,* and *barley.* The *potatoe* belongs to the *lime plants,* as far as regards the ingredients of its *leaves,* but its *tubers* (which contain only traces of lime) belong to the class of *potash plants.*

57. *What are phosphates?*

They are *salts* formed by a combination of *phosphoric acid,* with a substance or *base,* capable of uniting with an acid and forming a *neutral salt.* The phosphates of principal importance to agriculture are, the *phosphates* of *lime,* of *magnesia, potash, soda, alumina,* &c. Their composition may generally be illustrated by the *phosphate* of *lime,* the difference between it and the others depending upon the *base,* with which the *phosphoric acid* combines.

58. *What is phosphate of lime?*

It is a salt formed by a combination of *phosphoric acid,* with *lime* as a base. *Phosphoric acid* consists of *phosphorus* and *oxygen* in a state of *solution;* and a *phosphate* is *phosphoric acid* in a state of *combination,* with a *base,* forming what is termed a *salt.* Phosphate of lime constitutes the base of *bones of animals,* and is therefore an important ingredient in vegetables *employed as food.*

59. The bones of man, and of animals in general, have their origin from *phosphate of lime,* which is never absent from fertile land. The bone earth passes from the soil into *hay, straw,* and other kinds of food, which are afterwards *consumed by animals. Eight pounds* of *bones* contain as much phosphate of lime as *one thousand pounds* of *hay,* or of *wheat-straw,* and *twenty pounds* of *bones,* as much phosphoric acid as *one thousand pounds* of the *grain* of *wheat* or *oats.**

60. *What are sulphates?*

Sulphates are *salts formed by sulphuric acid* in combination

with any *base*, as *sulphate of lime*, *sulphate of soda*, *sulphate of alumina*, *potash*, *gypsum*, *magnesia*, &c. *Sulphuric acid* consists of *sulphur* and *oxygen* only, and is known as the *oil of vitriol* of commerce. In its pure state, it is an exceedingly sour and corrosive liquid, destroying both animal and vegetable structures; but, combined with *potash*, *soda*, *lime*, *magnesia*, &c., it contributes in certain instances to the fertility of the soil. It is rarely met with in nature in an *uncombined state.*

61. *Whence do plants obtain phosphate of lime?*

Phosphate of lime is found in natural soils, as are other phosphates, such as the phosphate of *alumina*, *ammonia*, *magnesia*, &c. The phosphate of lime is added to soils by the decay of vegetable and animal matter, and especially by *bones* and *shells.*

62. When alkaline or earthy *phosphates* are wanting in the soil, or when they are not introduced in the form of manure, *the seeds are not developed.* We may draw this conclusion, that the development of plants, and the amount of the constituents of the blood they contain, *are directly proportionate to the quantity of phosphates supplied to and taken up by them.* Phosphates, so necessary to the formation of the blood, and to all animal life, are *no less essential to the existence and to the propagation of all vegetable beings.**

63. *Whence do plants obtain sulphates?*

As far as our present knowledge extends, they *receive their sulphur from the sulphates dissolved in the water absorbed by their roots from the soil.* The water of springs is entirely

* Liebig.

"When first leaves cluster on the trees,
And spring flowers star the ground;
And birds come o'er the Southern seas,

derived from the rain which falls upon the surface of the earth; the water, percolating through the earth, dissolves all soluble materials which it may meet in its course. *The substances thus dissolved communicate to the water properties which are not possessed by pure water.* Thus rain precipitates the *ammonia* suspended in the air, and presents it to the roots of plants; at the same time that it presents *sulphur*, in some combined form, which it has met with in percolating the earth.

64. *What are alkalies?*

"*Alkali*" is a general term. It includes *all those substances* which have an action *like the ley of wood ashes*, which is used for soap making. If this ley is boiled down dry, it forms *potash*, as all know. Now *lime*, fresh slaked, *has the alkaline properties of potash*, but weaker, and so has the *calcined magnesia* of the shops, but in a *less degree* than lime. Here we have two substances, *earthy* in their look, *having alkaline properties*. They are called, therefore, ALKALINE EARTHS.

65. But what we understand CHIEFLY by the term *alkalies*, means *potash, soda*, and *ammonia*. POTASH is the alkali of LAND PLANTS; SODA is the alkali of SEA PLANTS; and AMMONIA is the alkali of ANIMAL SUBSTANCES.

66. Potash and soda are *fixed*; that is, *not easily raised in vapour* by fire. *Ammonia* ALWAYS *exists as vapour*, unless *fixed by something else*. Hence there is a distinction among alkalies which is easily remembered.

67. This distinction is *founded on the source from which they are procured*, and upon *their nature when heated.* Potash is a VEGETABLE alkali, derived from *land plants*; soda is a

"And build their nests, and sing aloud;
And insects, a gay and shining crowd,
Glitter, and hum around.

VEGETABLE alkali, derived from *sea plants;* ammonia is *animal* alkali, derived from *animal* substances. Potash and soda are FIXED ALKALIES; ammonia is a VOLATILE ALKALI.

68. Potash makes soft soap, with grease, and soda forms hard soap. Ammonia forms neither hard nor soft; it makes, with oil, a kind of ointment, used to rub a sore throat with, under the name of volatile liniment. But though there be three alkalies, and two alkaline earths, it should on no account be forgotten, that they all have common properties, called alkaline, and which will enable a person to understand their action, without anything being said about their chemistry.*

69. *The property of* alkalies *to be especially borne in mind in connection with agriculture is*—☞ *their great tendency to combine with* acids, *and form, by that combination, what are called neutral salts.*

70. *What are acids?*

Acids constitute a *numerous* class of chemical bodies. They occur in all the kingdoms of nature. Phosphoric acid, found in bones, is of animal origin; citric (lemon) acid and oxalic (sorrel) acid are of vegetable origin; carbonic acid and sulphuric acid are very common in mineral bodies, and are produced by breathing, burning, decomposition, &c.

71. As the word acid is, in common language, almost synonymous with *sour*, it might be supposed that the *taste* of a substance would determine whether it was included among the acids. The term has, however, been much extended by chemists beyond its original meaning, and includes bodies which are nearly, or quite, *devoid of sourness*, but are classed as acids because they agree with them in *some other* qualities. The acids are *generally* sour, but not *universally*.†

* Rev. J. Blake, D.D. † Penny Encyclopædia.

"When Winter comes, and beasts and men
Retreating from the field,
Seek fire-lit house and winter den;

72. We have said that acids, as well as being found in the bodies of animals and plants, by living processes, are produced by burning, &c. Let us illustrate their production by burning, because this will, to a great extent, assist the explanation of the other operations. Take a lucifer match, and ignite it by friction; this sets the *sulphur* burning. Now, the gas arising from the burning consists of the *sulphur* and *phosphorus* united to the *oxygen* of the air. This compound forms two acids, *sulphuric* and *phosphoric*. Then the *wood* burns, and its *carbon*, uniting also with *oxygen* from the air, forms *carbonic acid*. Thus no less than *three acids*, of peculiar, distinct, and important properties, are formed while burning a lucifer match.*

73. *The fact to be especially remembered with regard to* acids, *is the converse of that with regard to* alkalies.—☞ *All acids unite or combine with the alkalies and alkaline earths, forming neutral salts; and acids also combine with the metals. Thus they are actively and constantly engaged in the vegetative processes, and possess great powers of combination.*

74. *What are salts?*

Salts are ALL combinations of *acids* with *alkalies*, or, as they are called, *alkaline bases*. In their properties salts differ as widely as possible; some are crystallizable, others not so; some are colourless, others of various colours; some excite taste, others are insipid; some are soluble, others insoluble; some are volatile, others fixed.

75. The term *salt* is of wide and various application. But, in relation to the subject under consideration, the *common salt*, used as a seasoner and preserver of food, is a good example. This is the *chloride* of *sodium*, formed when *chlorine* and *sodium*, or *hydrochloric acid* and *soda*, come together.

76. *Sodium* is a soft metal of a silver-white colour, and light enough

* Rev. J. Blake, D.D.

to float upon water. In the metallic state it is *not known to occur in nature*, and, therefore, *does not directly act upon vegetation.* With *chlorine*, it forms the *chloride* of *sodium* (common salt), and in this form it is more or less beneficial to vegetation. With *oxygen* it forms *soda*; with *sulphur*, the *sulphuret of sodium*; and these salts are likewise variously beneficial to plants.*

77. Saltpetre is a salt. It is *potash* united to *aquafortis*. These have united, and their characters are neutralized by each other, so that in saltpetre one *will not perceive either potash or aquafortis*. They have formed a *neutral* salt.†

78. *What are "carbonates," "chlorides," "nitrates," "silicates," &c., frequently named in agriculture?*

These are some of the *salts* formed by the mutual action of ACIDS and ALKALIES, or, in some cases, METALS, already described.

79. Thus: the CARBONATES (carbonic acid) of *lime, magnesia, potash, soda, iron, manganese.*

CHLORIDES (chloric acid) of *potash, soda, lime, manganese, silver, zinc,* &c.

CITRATES (citric acid) of *potash* and *lime.*

HUMATES (the humic acid of soils) of *lime*, &c.

NITRATES (nitric acid) of *potash, soda, lime, ammonia, magnesia,* &c.

PHOSPHATES (acid of phosphorus) of *alumina, lime, magnesia, potash, soda,* &c.

SILICATES (acid of silica) of *potash, soda, lime, magnesia, alumina,* &c.

SULPHATES (sulphuric acid) of *ammonia, potash, soda, lime, magnesia, alumina, iron, copper, manganese,* &c.

* Johnston's Lectures. † Rev. J. Blake, D.D.

"Therefore, for us let seasons change;
Let the sun shine, or tempests rage;
Through street or forest still we'll range,

80. Thus it will be seen that the SAME ACID with ANOTHER BASE forms a DIFFERENT KIND of SALT.

81. ☞ *Many of these acids, alkalies, and salts, form essential constituents of animal and vegetable bodies, soils, and manures; and the changes and combinations which they undergo are intimately connected with the development of animal and vegetable life, and the growth of animal and vegetable forms.*

82. *What are bases.*

The term *base* implies the *leading constituent of a compound.* Thus, in the compound "*carbonate of lime,*" the latter is the *alkaline earthy base.*

83. Every one is acquainted with the general properties of that group of substances which bears the name of *acids.* The term BASE is perhaps, not so universally understood. We designate compounds possessing the power of combining with acids and neutralizing their acid properties, by the word BASES. A compound of an *acid* with a *base* is denominated a SALT (this name has no reference to the taste). Now, in these compounds—in salts—*one base may be made to replace another base, one acid another acid.**

84. Carbonic acid, water, ammonia, and sulphates, are necessary for the existence of plants, *because they contain the elements of which their organs are formed.* But, *other substances are requisite for the formation of certain organs destined for* SPECIAL FUNCTIONS *peculiar to each family of plants.*

85. Most plants, perhaps all of them, contain organic acids of very different composition and properties, all of which are in combination with BASES, such as *potash, soda, lime,* or *magnesia*; plants containing *free* organic acids are few in number. The *bases* evidently regulate the formation of the *acids* for the *diminution of the one* is followed by a *decrease of the other:* thus in the *grape,* for example, the quantity of *acid* contained in its juice is less when it is *ripe,* than when *unripe;* and the *bases,* under the same circumstances, are *found to vary* in a

* Liebig.

"*And find God present in each spot;*
His guiding hand in every lot;
His grace from age to age!"—W. Howitt.

similar manner. Such constituents exist in the smallest quantity in those parts of a plant in which the process of assimilation is most active, as in the mass of woody fibre; and their quantity is greatest in those organs whose office it is to prepare substances conveyed to them for assimilation by other parts. The *leaves* contain more inorganic matters than the stem.*

86. It is most important to bear in mind that any one of the many alkaline bases may be substituted for another, the action of all being the same.

87. The law that one base may be substituted for another is of the highest practical value. This will be perceived, when it is considered, that if a soil, containing originally all the elements essential to a crop, becomes exhausted of one, yet another may be substituted; which, combining with the organic acid of the plant, enables it to perform and perfect all its functions; *potash, soda, magnesia*, &c., may, in certain circumstances, supply the place of lime.* When roots find their more appropriate base in sufficient quantity, they will take up less of another.†

88. *The base of all salts acts ever the same in agriculture.* Peculiarity *of action depends upon the* acid *of the salt.* This is the great practical principle of agricultural chemistry. It opens veins, rich in results, more precious than mines of gold.†

89. It is not known in *what* form *manganese* and *oxide of iron*, are *contained in plants;* but we are certain that *potash, soda,* and *magnesia* can be *extracted*, by means of water, *from all parts of their structure*, in the form of *salts* and *organic acids*. The same is the case with *lime*, in many instances. The existence of *vegetable alkalies*, in combination with *organic acids*, gives great weight to the opinion that *alkaline bases* in general *are connected with the development of plants.*

90. The ashes of the *tobacco plant*, of the *vine*, of *peas*, and of *clover* contain *a large quantity of lime.* Such plants *do not flourish on soils*

* Liebig. † Dr. S L. Dana.

"Welcome, ye plump green meads,
Ye streams and sighing reeds;
Welcome, ye corn-fields, waving like a sea!"—CHARLES MACKAY.

devoid of lime. By the addition of salts of lime to such soils, they *become fitted* for the growth of these plants; for we have every reason to believe that their development *especially depends* upon the presence of *lime*. The presence of *magnesia* is equally essential, there being many plants, such as the different varieties of *beet* and *potatoes*, from which it is NEVER ABSENT.*

91. The whole argument suggests, that by the analysis of plants we may arrive at a knowledge of their peculiar wants, and by the chemical examination of soils and manures, we may take care that those wants are supplied.

92. *Whence do plants obtain their principal salt?*

It has been proved, that with the evaporation of salt water, *salt becomes volatilized* and dispersed. When sea storms occur, the leaves of plants in the direction of the wind are covered with crystals of salt, even to a distance inland of from twenty to thirty miles.

93. But it does not require *a storm* to cause the volatilization of the salt, for the air hanging over the sea always contains this substance, and every breeze must carry it away. Now as thousands (millions) of tons of sea water annually evaporate into the atmosphere, a corresponding quantity of the salts dissolved in it, viz., *common salt, chloride of potassium, magnesia*, and the remaining constituents of sea water, will be conveyed by the wind to the land.

94. *By the continual evaporation of the sea, its salts are spread over the whole surface of the earth;* and being subsequently carried down by the rain, *furnish to vegetation those salts necessary to its existence.* This is the origin of the salts found in the ashes of plants, *in those cases where the soil could not have yielded it to them.**

* Liebig.

"Thus shines the present, safe from war's alarms—
You till in peace your old ancestral farms;
Blithe with the spring the busy task begin,
And feast at autumn, when the harvest's in."—Batchelder.

95. By the foregoing explanations, the substances to be found in plants—which is the same to be found in manures and soils on which plants grow—are *reduced from things not known, to things that are known.* In this way, persons may feel familiarised with them without a deep acquaintance with *chemical science.* And it will be seen that in a multitude of cases the practical cultivators of the soil may understand the PRINCIPLES of the science, although ignorant of the precise *terms* which represent and explain these principles. Thus the housewife proceeds in making bread on scientific principles, *although she never saw a book on chemistry, or learned the meaning of a scientific term.***

96. *In what respects does nature present to man the example of preparing soils?*

By the gradual processes by which she herself *prepares the surface of the earth,* in certain instances, *for the reception of the higher orders of plants.*

97. What is the common action of nature upon a bare rock which is protruded in any way? You first have some *lichens* growing over the surface of the rock. These plants have the power, *without the aid of anything from the soil except the mineral ingredients,* of *attracting substances from the air.* After generations of these have grown and died, *mosses* take their place, and *grow upon the remains of a kind of mould* which has been made *by the decay of the lichens.* After the *moss* has grown for some years, you will find different kinds of *natural grasses.* These are succeeded by others, until at last you have upon what was originally a bare rock, *a soil formed naturally,* in which *trees* can and do grow, from seeds naturally sown in it.

98. Take, for example, the *lavas* ejected from Vesuvius, Ætna, and other volcanoes. These lavas, which have been molten and red hot, of course contain no vegetable matter. They have not been long cooled before the wild fig-tree and other plants, sending their rootlets into the interstices, spring up and produce abundance of woody matter, which must evidently have been *obtained from the air,* as it *did not exist* in the *soil.* It is clear, then, that there is SOMETHING *in the air* which

* Rev. J. Blake, D.D.

"Where vetches, pulse and tares, have stood,
And stalks of lupine grew (a stubborn wood),
The ensuing season in return may bear
The bearded product of the golden year."—DRYDEN'S VIRGIL.

these *plants* have the power of obtaining; and it is this which enables nature *to clothe the surface of different rocks, with plants of various kinds, so as to present, even when man does not come on the stage at all, a fine scene of foliage wherever moisture and water, and other elements of vegetation can be found.**

99. *Why are there various kinds of soils, possessing different degrees of productiveness?*

The *differences of soils* are, to a very great extent, explained by the *geological* characteristics of the localities in which they exist. Any one who has observed the appearance of large rocky masses, the clefts and crevices they present, the bare surface of their smoother and harder parts; the growth of mosses and smaller plants on the more softened portions; the accumulations of gravel, smaller fragments of minerals, and fine mud, with their luxuriant vegetation at the foot of these rocks, and in the valleys of mountainous districts, must be aware of the importance of these ever-continuing operations in nature.

100. Thus, *soils originate in the disintegration and decomposition of solid rocks* in their immediate neighbourhood, especially of those which occupy the eminences. But as *rocks differ much in their composition*, the soils which are formed on their degradation must necessarily present, in many cases, great differences *equally with the rocks themselves.*

101. But, in other instances, the nature of the soils in a given locality, partakes *nothing of the character of the rocks in the immediate neighbourhood*, nor even of those upon which they rest. The first class of soils to which we have referred, are those which may be said to arise from

* Nesbit's "Agricultural Chemistry."

> "All things have something more than barren use:
> There is a scent upon the briar
> A tremulous splendour in the autumn dews,
> Cold morns are fringed with fire."—ALEX. SMITH.

"*mechanical causes;*" the others, the origin of which is more difficult of explanation, arise from "*chemical causes,*" and in the production of others, *both these causes are combined.**

102. Among the *mechanical* causes which operate in the disintegration of rocks may be mentioned the action of *winds, rains, streams of water,* and the tendency of all bodies when moved in elevated situations to *gravitate towards the centre of the earth.*

103. Among the *chemical causes,* are the action of the *gases* of the *atmosphere* upon *mineral surfaces;* the action of the *sun's rays;* and of the *fermentive processes* wherever accumulations of organic substances take place. To these causes may be added the action of *living beings* upon *all classes of substances.*

104. All rocks, and indeed almost all mineral substances, have a greater or less tendency to *combine with the oxygen of the atmosphere,* especially when under favourable circumstances of *heat* and *moisture,* and probably also of *electricity* and *light. Carbonic acid* and *water,* also, are absorbed by rocks in considerable quantity; and the *effect* of these combinations, whether chemical or mechanical, is *to loosen the cohesion between the particles of stone, and induce a tendency to disintegration.* This separation of the parts is very much accelerated by those sudden expansions and contractions which are occasioned by changes of temperature, and especially during frost, when the imbibed moisture is *converted into ice.* This slow and silent work of waste is unremittingly going on wherever rocks are exposed to the weather. No species of stone is exempt; and even granite, which in general is so little subject to change as to be proverbially a symbol of endurance, and is selected for our bridges and other great works of architecture, under peculiar circumstances of constitution and exposure, is remarkably disposed to this process of crumbling. The granite of some parts of Finland is so liable to decomposition, that masses of it may be cut down and shaped in the same manner as a hay-rick.

105. To devise an arrangement of soils, at once comprehensive and distinct, is no easy task. The distinctions ought to be simple and obvious, without regard to minute differences, which may be of no

* Moreton's "Cyclopædia of Agriculture."

"The grist-mill stands beside the stream,
With bending roof and leaning wall;
So old, that when the winds are wild,
The miller trembles lest it fall."—STODDARD.

material importance. FOR PRACTICAL PURPOSES, soils may be classed under the following general heads:—SAND, GRAVEL, CLAY, CHALK, PEAT, ALLUVIAL, MARSH, and LOAM, or that species of artificial soil into which the others are generally brought by the effects of manure, and of earthy applications in the course of cultivation.*

106. *What is the origin of sandy soils?*

Most sands, whether on the surface of the ground, or in strata at a certain depth; whether forming the beds of rivers, or the shores of the sea, are the *fragments of disintegrated rocks*, and are red, white, grey, or black, according to the rocks from which they were derived. The grains *of sand are, for the most part, composed of silica*, and soils containing it are called *silicious.*

107. Sand is probably formed for the most part of *quartz*, as it does not differ materially from that mineral in its chemical composition. Immense floods of water, the action of the atmosphere, and probably also that of fire and other agents, have reduced quartz to fragments which have subsequently acquired a rounded form by rubbing against each other, in consequence of the motion communicated to them by air and water.

108. *River sand* is deposited by the waters of springs and rivers.

109. *Pearl sand*, having lain imprisoned in the earth, is larger than ordinary sand; it is frequently found below the surface, and is sometimes washed up, and deposited by springs of water.

110. *Moving sand*—which is frequently heaped up in valleys by currents of air and water—is generally mixed with various heterogeneous matters, with which it becomes associated by shifting; it generally carries with it *alumina, lime, &c.*

111. *How may sandy soils be improved?*

By a mixture of clay, marl, or warp (the sediment of navigable rivers), sea-ooze, sea-shells, peat, or vegetable earth. *It frequently happens, that under the sand itself, or in*

* Sir John Sinclair's "Code of Agriculture."

> "From the moist meadow to the withered hill,
> Led by the breeze, the vivid verdure runs
> And swells, and deepens to the cherished eye."—THOMSON.

its immediate neighbourhood, the materials may be found which are requisite for its improvement. Even light sandy soils may be rendered retentive of moisture and manure, when mixed with the subsoil, or ameliorated by admixture with other soils.

112. In the management of sandy soils, three rules are to be observed:—1. Never to pick off any small stones that may be found in them, as they answer many valuable purposes: they shelter the young plant in bad weather; they preserve moisture, and prevent the crops from being burnt up by scorching heats; they hinder the evaporation of the enriching juices; and, by these means, greatly assist the progress of vegetation. 2. Frequently to renovate the strength of such soils, by laying them down with grass-seeds, and pasturing them for a few years, as they are apt to be exhausted by ploughing, if corn crops are too frequently repeated; and—3. When farm-yard dung is applied to this description of soil, always to give it in a state of compost, with a view of adding to the tenacity of the soil, and of preventing the manure from being dissipated in a dry season, or washed down by rain.*

113. *Example of Improvement.*—The north and west of the county of Norfolk forms an immense sandy plain of 750,000 acres, where there is no obstacle to large property and large farming, and where everything favours horse-tillage, cultivation of roots, the use of machines—in one word, the four-course rotation. By means of this system, steadily pursued for sixty years, these inferior lands, producing scarcely 5s. per acre in 1780, now return on an average 25s. per acre, or five times their former net production, and the gross production has risen in at least an equal proportion.

114. A large part of the credit due to this wonderful transformation, belongs to an extensive proprietor in the county, Mr. Coke, who, in acknowledgment of his services to agriculture, was created Earl of Leicester. He died a few years ago, at an age not far short of a hundred. Mr. Coke had a large property in the west of the county, called Holkham, containing about thirty thousand acres. This immense estate, which is now worth at least £1,200,000, was worth at most £300,000 in 1776, when Mr. Coke inherited it. It was then in the

* Sir John Sinclair.

"Each morning now the weeders meet
To cut the thistle from the wheat,
And ruin in the sunny hours
Full many a wild weed with its flowers."—CLARE.

occupation of a great number of small farmers, who paid their rents with difficulty, although these were very low; and ultimately a great many of them abandoned their farms altogether, because they could not make a living out of them. It was then that Mr. Coke decided upon farming a portion of these sandy wastes himself; the rest he put into very large farms, and, by offering leases of twenty-one years, held out an inducement to farmers of intelligence and capital to take them. The farm which Lord Leicester personally directed lies in the park belonging to the mansion. Its extent is 1800 acres, 500 of which are permanent pasture; the rest is arable, laid out exactly for the four-course rotation. The farm maintains 250 large cattle, 2,500 sheep, and 150 pigs.*

115. *What is the origin of gravelly soils?*

Gravel is a description of sand, but consisting of *larger particles of disintegrated rocks*, distributed over the face of the earth, chiefly *by the action of water*. Gravel, having been dispersed by a more powerful agency than that which caused the distribution of sand, differs more widely in its qualities, because of its frequent admixture with various substances, organic remains in a fossil state, and especially *clay*, *loam*, *flints*, *iron-stones*, &c. Hence there are *rich gravels*, *poor gravels*, *hungry gravels*, *sharp gravels*, *&c.*

116. Sands will frequently be found to be the production of flat countries, gravels of the mountainous and rocky. The characteristic of gravelly soils, is the quantity of loose stones which they contain. These stones will be found to consist of those varieties of rocks which the mountains of the country afford; and the nature of those rocks will frequently indicate the characters of the soil; thus, soils of which the stony matter is silicious, are generally found to be barren, while those of which it is calcareous, are found to be fertile.†

* Lavergne's "Rural Economy of England." † Lowe's "Practical Agriculture."

> "Seed well prepar'd and warm'd with glowing lime,
> 'Gainst earth-bred grubs, and cold, and lapse of time;
> For searching frost and various ills invade,
> Whilst wintry months depress the springing blade."—BLOOMFIELD.

117. *How may gravelly soils be improved?*

By *draining*, if they are troubled with springs, which is frequently the case; by ploughing rather deep; by mixing them with large quantities of clay, chalk, marl, peat, or other earth; by frequent returns of grass crops; by repeated applications of manure; and by irrigation, more especially if the water be full of sediment and judiciously applied.*

118. *The materials to be added to gravelly soils* of a calcareous nature, to increase their fertility, are clay and clay loam. A mixture of carbonate of lime or chalk with clay, has also appeared beneficial to such soils. Chalk is particularly recommended for those kinds of gravelly soil which contiguity to springs is apt to render moist in the winter season. The application of chalk is stated as having a powerful effect, not only in counteracting the redundant moisture, but in correcting the tendency to become parched in the summer—an evil to which most gravels are in some degree liable, and which is often so injurious to the crop.

119. *The defect of vegetable and animal matters* is to be supplied by means of dung from the farm, in its reduced state; and much benefit is derived from other animal matters, prepared in the form of composts, with good loamy mould, ashes, clay, depositions of rivers and ponds, with other substances of a similar nature. The proper alternation of green vegetable, and other crops, also contributes greatly to improve the fertility of such lands.†

120. *What is the origin of clayey soils?*

Clay is a *mixed natural earth*, very widely distributed. It consists of a large proportion of *alumina*, united to *silica*, of various degrees of fineness, and frequently also a portion of *carbonate of lime.*

121. The formation of clay deposits took place, according to geological theory, in consequence of the degradation and

* Sir John Sinclair. † Encyclop. Edinensis: Art. "Agriculture."

"Hour after hour, and day to day succeeds,
Till every clod and deep-drawn furrow spreads
To crumbling mould, a levelled surface clear,
And strew'd with corn to crown the rising year."—BLOOMFIELD.

waste of certain portions of the globe, *followed by a removal of the materials to localities of comparative tranquillity.* In the formation of clayey deposits both chemical and mechanical agencies were exerted.

122. The *mechanical* agency operated in the disintegration of solid parts, and the removal of the fragments; and the *chemical* agency operated in the uniting of alumina, silica, &c., into a compact earth.

123. *A clay* soil is distinguished above every other for its *tenacity.* It is principally composed of particles of matter, many of them so small, that when separated from each other, they are imperceptible to the touch, and will easily float in water; yet these minute particles form a soil, that is *far more tenacious than any other species of earth.*

124. Clay always contains *iron*, in a higher or lower degree of *oxidation*; and it is probable that this metal constitutes an essential part of it.

125. *How may clayey soils be improved?*

By a suitable *admixture of other soils* to ameliorate its texture, such as *common sand, sea sand,* and above all *limestone gravel.* Peat moss, which has for some time been dug up and exposed to the action of the atmosphere, may be used with advantage. It is likewise necessary, in the course of its cultivation, to enrich it with putrid and calcareous manures; and it may be much improved by having a considerable quantity of *ashes* mixed with its putrescent manures. *Burning part of the clay,* to be afterwards incorporated with the soil, to render it more friable, has likewise been attended, in some instances, with advantage, more especially if there is any marl in its composition.

"Ye happy fields, unknown to noise and strife,
The kind rewarders of industrious life."—GAY.

126. *Example of Improvement.*—Were I to fix on the land which, in my opinion, would be most benefited by the plough, and which, under a proper cultivation, would probably produce almost as good crops of wheat as the very best land, it would be a cold soil on stiff blue clay. Land of this quality, while under grass, is never of much value, either to the owner or the occupier, and is of little or no use to the community, as the food produced on it is very inconsiderable indeed. On breaking it up and managing it in a husband-like manner, a new order of things arises; from being the abode of poverty, it becomes the source of plenty, and repays the cultivator tenfold for his expense and trouble.

127. Having, some years since, entered upon a farm of this nature, which I flatter myself is considerably improved, I shall presume to submit my mode of management.

128. As the land was extremely poor and wet, my first object was to lay it dry; and having ascertained the cause, I drained it, either by tapping, or by hollow draining it up each furrow, at the distance of from seven to ten yards, as the nature of the case required; but it must not be concealed that hollow draining in soils of this nature is generally the most requisite.

129. Draining I consider to be absolutely necessary, if any permanent improvement is intended, as *nothing so amply repays the expense;* for it not only prevents the rot in sheep when fed, but the manure lasts longer, it requires less seed, bears considerably better crops, which are ripe by more than a fortnight sooner than those which grow on lands not drained; and, as a still greater advantage, two horses will be sufficient to work it, where three were before required.

130. The land being thus prepared at my own charge, I broke up a part of it, and sowed it with oats; the remainder I floated and burnt. In doing this, I took particular care to pare as thin as possible; and as black ashes are highly advantageous, from the quantity of salts they contain, I took particular care to burn the turf in very gentle fires, in order that *the salts might not evaporate,* which would have happened, had the turf been burnt to a brickish red. These ashes I spread upon the land, and then ploughed it and sowed it with turnips: I was, however, cautious to plough thin, in order that the turnips might have the benefit of the ashes.

"Ye generous Britons, venerate the plough,
And o'er your hills and long withdrawing vales
Let Autumn spread his treasures to the sun,
Luxuriant and unbounded!"—THOMSON.

131. This plan, I believe, is not common, for it is usual after burning to sow with wheat, but I give the preference to a turnip crop, from the great improvement which the land receives by eating them off with sheep. And here I must remark, that having hollow-drained the land, I found it as well adapted for feeding sheep as the lightest soil, and have no doubt but that clay land, if drained, would invariably be well adapted for the purpose.

132. My next crop was barley laid down with clover, fourteen pounds per acre; this I fed the summer following with sheep, which should always be done, for mowing the clover certainly tends to impoverish the ground. In the autumn I again broke up the land, ploughing in a good quantity of clover, and sowed it with wheat. When this was harvested, and Candlemas arrived, I fallowed the land; and as soon as the spring seed time was over, I spread from seventeen to twenty tons of manure a year old, (for I find new manure to retain the wet so much, that it is disadvantageous to wet soils) per acre; I then ploughed it in, used a scuffle, and worked the land till quite clean—being of opinion that a scuffle, from its mixing the manure with the soil, as well as from its increasing the quantity of soil, is better adapted at this period for the purpose than a plough. I afterwards, at a proper time, ploughed and sowed with turnips, and eat them off with sheep as before, making it a point to clear the land before Candlemas, which gives the soil an opportunity to be lightened by the frosts, and produces a better crop of corn afterwards.

133. Having now brought the land into such a state, that it is either fit to be continued under the plough, or to be laid down considerably improved; if the former is resolved on, I sow with barley and clover, and follow with wheat and turnips, as before described; but if I wish to lay it down, I sow it with barley and the following seeds: nine pounds of white clover; five pounds of red clover; three pounds of trefoil; one gallon of rye grass; and on every account recommend the land to be fed for some time with sheep before it is mown.

134. Having thus stated my course of husbandry, I must add, that at the time I entered upon the land, it was not worth more than 10*s*. per acre; whereas, I now pay £1 for it, notwithstanding I have been at the sole expense of improving it; and that as grazing land, it did not produce per acre, at most, more than *fifty pounds of human food;*

> 'Go mark the matchless working of the Power
> That shuts within the seed the future flower,
> Bids these in elegance of form excel;
> In colour these; and those delight the smell."—COWPER.

whereas, it now *produces five hundred pounds of solid food, deducting five hundred pounds as offal, on an average of four years, per acre.**

135. *What is the origin of chalky soils?*

Chalky soils, like those of clay, are referrible to geological agencies in the early history of the earth. *Lime*, *magnesia*, &c., being dissolved, or disintegrated by the action of water, were spread over vast surfaces, and afterwards precipitated, forming *chalky strata*.

136. We find similar processes in operation at the present time, in the production of chalky marls, and irregular accumulations of limestone in lakes, and at the mouths of some rivers.†

137. The chalk formation extends over the south-eastern and eastern counties of England, the north of France, Germany, and the north of Europe. The chalk strata vary from a thousand feet in depth to a few feet only. Chalk is characterized by containing certain fossils, and especially by containing flints.

138. *How may chalky soils be improved?*

Either by the application of *clayey and sandy loams*, or pure *clay marl*, the use of great quantities of *peat*, or of *water-fed earth*. A chalk stratum probably will be found to lie upon a thick bed of blue or tenacious marl, of a rich quality, which *ought to be dug up* and mixed with the chalk, to cure its defects as well as to enrich it.

139. A chalky soil that has been in tillage, permits water to pass through it so freely in winter, and is so pervious to the sun's rays in

* Communication by Mr. John Bourdon, of Rotherby, Leicestershire, to the Board of Agriculture.

† See the "Geological Reason Why."

"Earth fills her lap with pleasures of her own,
Yearnings she hath in her own natural kind,
And even something of a mother's mind."—WORDSWORTH.

summer, that it is the work of an age to make it a good pasture of *natural grasses*, more especially when the chalk lies near the surface. Hence, in certain instances, several thousands of acres of this soil, though not ploughed for thirty years, have scarcely any grass of tolerable quality upon them, and are literally worth nothing. Such soils ought to be cultivated, as a preparation for sainfoin, in the following manner: 1st year, Pare and burn for turnips, to be eaten on the land by sheep, with the aid of some fodder; 2nd, Barley to be sown very early with clover seed; 3rd, Clover, eaten off by sheep; 4th, Wheat; 5th, Turnips, with manure; and 6th, Barley, with sainfoin. The corn crops must be carefully weeded, and in particular, cleared of charlock.*

140. *Example of Improvement.*—To convert grass land on chalk soil into *tillage*, is one of the most advantageous improvements in agriculture, if properly conducted. Old downs, that are frequently unproductive of any valuable herbage, may, in a very short space of time, and at little expense, be brought to *yield the most abundant crops of corn*;—of *barley*, no land whatever produces better crops, nor finer samples, and when put under a proper system of tillage, good *wheat* may also be obtained.

141. The method is to *pare and burn*, in the first instance, a turf as thick as can be cut to burn well; let the burning be finished as soon as possible in the spring, the ashes spread, and the land ploughed three or four inches deep; harrowing and rolling it down smooth immediately after the plough, to keep in the moisture. In the last week in June, let it be cross-ploughed about five inches deep, to mix the ashes intimately with the mould; then sow the land with *turnips*, if a *dry season*, by *drilling*, as that mode lets the seed down among the moist earth; but if the season be *rainy*, sowing *broad-cast* will answer the purpose of a quick vegetation equally well. The drill system is, however, the best, as it gives a better opportunity of eradicating by the hoe, the seedling weeds, that on these old downs are generally found; particularly charlock, than which nothing is more pernicious. Every plant, that is left and seen in bloom among the turnips in the autumn, must be drawn out carefully by hand, as otherwise a little fine weather, in the early part of the winter, will ripen the seed, and a few frosty days after will shake it out on the land, where it will remain

* Sir John Sinclair.

"The plough moves heavily, and strong the soil,
And clogging harrows with augmented toil
Dive deep: and clinging, mixes with the mould
A fattening treasure from the nightly fold."—BLOOMFIELD.

to vegetate in future, a plague to the farmer, and destruction to his crops. The turnips must be *eaten off by sheep* living upon the land night and day, having a quantity set out with hurdles, fresh for them as occasion may require, with a daily allowance of podware or trefoil-straw for lean, and hay for fattening, sheep. Some fodder is absolutely necessary, as *turnips alone*, especially in wet weather, are very *unwholesome*. To fatten sheep on turnips with *oil-cake* is the greatest improvement, and, however the farmer may be, in some respects, a loser by feeding sheep in this way, his loss will certainly be repaid ten-fold in his future crops of corn.

142. Instances can be brought in proof, if thought necessary, of crops of corn being raised by this means to be worth *sixty times the annual rent of the land.* After the turnips are consumed, the land should be ploughed about four inches deep as speedily as possible, and sown with *barley*, and *clover-seed*; the sooner, in the spring, provided the land be not very wet at the time of sowing, the more valuable in general will be the produce. Every weed that is seen among the barley must be taken out by hand; and if the cultivator has any reason to suppose, that there is a great abundance of the seeds of weeds remaining in the soil after the first crop of turnips, a second should be raised the following summer, in order to get the land completely clean before he ventures upon crops of corn.

143. The crops of *clover* should be *eaten off by sheep* lying upon the land, and, if it can be accomplished, the lay may be folded in the end of summer, ploughing it afterwards five inches deep, to be sown with *wheat* in the month of October, or early in November. Every weed found among the wheat in the month of June, and early in July, should be carefully taken out by hand; and, as soon as convenient after harvest, the land should be ploughed about five or six inches deep. The land, having by this rotation produced two stout crops of corn, is entitled to a portion of *manure* equal to what has arisen from it, which, mixed with mould as before directed, will afford a tolerable covering for another crop of turnips. These being eaten in the field as before, the land is left in fine order to accomplish the object required, viz.:—"*returning to grass without injury*;" indeed, so far from injury, these soils will, on the contrary, be highly improved for every kind of grass, but more particularly for *sainfoin*; abundant crops of

"Nor is the profit small the peasant makes
Who smooths with harrows, or who pounds with rakes,
The crumbling clods."—DRYDEN'S VIRGIL.

which have frequently been raised under this management, on lands of this description, by the writer of this essay.*

144. Salisbury Plain presents to the eye the appearance of a deserted country, where a few farms, at great distances from each other, are hid from view in the hollows, and where fields of corn, without a tree or a fence, extend as far as the eye can reach. These immense tracts were formerly used only for *sheep pastures*.† The visitors to Salisbury Plain at the Agricultural Show of 1857, were surprised to find a large part of it converted into productive *corn-land*—a change which has been almost entirely effected within the last twenty years.‡

145. *What is the origin of peaty soils?*

Peat consists of an accumulation of *vegetable matter*, in a state of greater or less decomposition. It is generally found *in low*, moist situations, where *mosses*, *lichens*, and other plants grow, which are with difficulty decomposed; these become interwoven, and unite with the mud and various substances deposited by the water; the whole amalgamates, the vegetables putrefy, and gradually lose their organic texture, and are at length united with the other substances into a compact spongy mass.

146. There is this obvious difference in the origin of peat soils, and those of *sand*, *chalk*, *gravel*, *clay*, &c.; the latter have been formed by the *geological operations of nature*, and generally *brought from a distance*, and deposited, by the action of water; *but peat soils have been formed wherever they now exist*.

147. A soil covered with peat, is a soil covered not only with fuel, but also with manure. *It is the* EXCESS *of manure only which is detrimental*; and it is much more easy to destroy than to create it. To cultivate a bog is a much less difficult task than to improve a sand. If

* Mr. Boy's "Essay on the means of converting Grass Land into Tillage."
† Lavergne's "Rural Economy." ‡ Quarterly Review, 1858.

there is a proper level to admit of draining, the larger the scale of operation, the less the comparative expense must be, because machinery for many purposes takes the place of manual labour.*

148. As peat is formed by the decay of various kinds of plants, so it will be found to differ in its qualities. Nothing so clearly indicates the quality of peat as *the plants which it spontaneously produces*, for the moss soil and its products are nearly the same substance, and the crop of the preceding year is the soil in which the next year's crop vegetates. Again, the moss plants now vegetating indicate the degree of moisture; for, as soon as a permanent saturation is effected, the *sphagnum*, &c., is produced, to the almost total exclusion of the other plants; but, on the water being drawn off, it dies, and is succeeded by heath and sundry coarse aquatic grasses; or, if rendered sufficiently dry, bent-grass prevails. If decomposition is by any means effected, then rushes, and also the finer pasture grasses supplant the latter. While moss plants continue to grow, it is evident that the depth of the moss must be still on the increase, and this by means of the antiseptic qualities of its products; but where, by any means, pasture grasses, or even rushes abound, it is manifest that the proper moss is in a state of decay; decomposition has commenced, and a very different soil is presented, and, of course, a different treatment is called for.†

149. Peat soils include a large proportion of several counties of Great Britain and Ireland. In the Falkland Islands almost every kind of plant, even the coarse grass which covers the whole of the surface of the islands, becomes converted into this substance. In the Terra del Fuego, nearly every patch of ground is covered by two species of plants, which, by their joint decay, compose a thick bed of elastic peat.

150. *How may peaty soils be improved?*

The first step of improvement is to *acquire command of the water*, and obtain an outfall, by digging a ditch, which will take the place of the winding stagnant rivulet, frequently found in bogs. A system of draining must then be pursued, adapted to the extent of the ground, and the levels that can be obtained. The draining completed, *paring and burning*

* Sir Humphry Davy. † Mr. Blackadder.

"Thence from its chalky bed behold convey'd
The rich manure that drenching winter made,
Which pil'd near home grows green with many a weed
A promis'd nutriment for Autumn's seed."—BLOOMFIELD.

should be followed. When the dry easterly winds of spring set in, the breast-ploughs should be put to work, the surface pared and turned over, and, when dry, piled in heaps, and burned to ashes.

151. *Rape*, or *seeds* being established as the first crop, after the breaking-up, the next crop is usually *oats*. They are drilled in upon a very shallow furrow, with plenty of seed, and well pressed with a press-roll, as well before they have come up as afterwards, in order to guard against the wire-worm, the enemy to be feared on such land. This first crop of oats is generally beaten down by the weather, being weak and long in the straw; and though not a bad crop, looks better than it really is.

152. On land which is not peat, but *peaty*, some farmers grow *barley*. There is a large crop of straw, and it is, therefore, liable to be laid; the grain, too, is thin. The advocates of barley, however, assert that a bad sample of barley is better than a bad one of oats, because thin barley may be ground, or may be used for seed, whereas seed oats should be as plump as can be found.

153. The oats or barley are followed by *rye-grass*, which has been sown among them; but, if these have been laid, as they often are, large patches of the rye-grass will soon be destroyed.

154. When *wheat* is sown on ground that is at all peaty, it will almost certainly lose plant in large patches, even though the land has been dunged, and the young wheat has been trodden in by women, as is sometimes done. This is because there is some principle defective in the soil; that principle is *cohesion*, and can only be supplied by clay. The fen farmers of Lincolnshire, accordingly, apply clay to peat land, by a process which has been carried on for many years.*

155. Mr. Cuthbert Johnson disapproves of the practice of paring and burning, being of opinion that it merely furnishes the soil, by an expensively rapid process, with the freed earths of the peat, which its gradual decomposition would, by other modes, more profitably and

* Abridged from a paper "On the Practice of English Farmers in the Improvement of Peaty Ground," by Ph. Pusey, Esq., M.P. Journal of the Royal Agricultural Society, Vol. II.

While yet the Spring is young, while earth unbinds
Her frozen bosom to the western winds,
Even in this early dawning of the year
Produce the plough, and yoke the sturdy steer."—DRYDEN'S VIRGIL.

steadily effect. He recommends the breaking-up as deeply as possible, by the common and the subsoil ploughs, the surface of the peat; and then, if good well-burnt lime can be procured, there is no earthy addition so rapid and so powerful in dissolving and rendering pliable the peat as this. A few ploughings, assisting the combined operations of the atmosphere and the lime, will in a few weeks bring the soil into such a state as to enable it to bear a first crop. The quantity of lime should be about 250 or 300 bushels per acre; but the quantity, of necessity, must vary with the readiness with which the lime is procurable. Where it is very expensive, the cultivator is obliged either to reduce the quantity, or mix it thoroughly with a proportion of clay or marl, before he spreads it over the surface of the peat. Where limestone is to be obtained in the immediate neighbourhood, and other fuel is not to be readily procured, peat may be employed in many cases in the process of lime-burning without much difficulty, it chiefly requiring that the peat should be thoroughly dried previous to its being used.

156. For a *first crop* on the thus reclaimed peat soils, I have found no other crop equal to *potatoes*. These are best planted in ridges; the horse hoe-plough can then be easily kept at work, which not only considerably promotes the decomposition of the peat, by facilitating the introduction of the moisture and gases of the atmosphere; but this operation adds very materially to the vigour and produce of this valuable root, than which no plant more delights in fresh soils, such as that produced by well-drained fresh earth-dressed peaty lands.

157. It is well to avoid for a year or two all attempts to produce *corn crops* on land like that now described. The course of cropping which the farmer will almost always find the most profitable, is to follow the *potatoes* with *peas*, then *turnips*, *oats*, *grass-seeds*, *peas*, *wheat*. In all cases, too, he must remember in what small proportions some of the essential ingredients of his crops are at first existing in this peaty soil, and how valuable even a slight dressing of clay or marl will be found in supplying such deficiencies.*

158. *Example of Improvement.*—The fens of Lincolnshire have been increased in productiveness at least 100 per cent., merely by

* Journal of the Royal Agricultural Society.

"Our guarded fields a sense of danger show
Where garden crops with corn and clover grow,
Fences are thickly form'd and plac'd around
(With tenters tipp'd)—a strong repulsive bound."—CRABBE.

applying to the surface of the peat, the clay which is found at depths varying from two to five feet below it.

159. This application is made thus:—Trenches, parallel to one another, are made, 11 yards apart and 3 feet wide, down to the clay; and then 2 feet in depth of the clay is thrown out, one-half on each side. The effect of this, after the second year, is greatly to increase the productiveness of the soil—in many cases to double it.

160. This mode of improving peaty soils extends over a very large district; indeed it is equal in extent to the extent of the fens, for, although the whole of the fen-land in Lincolnshire, Northamptonshire, Huntingdonshire, and Cambridgeshire, has not been so treated, yet there is scarcely a farmer but has begun and is now proceeding with this important improvement.*

161. *What is the origin of alluvial soils?*

Alluvial soils are formed by those accumulations of *sand, earth,* and *loose stones* or *gravel,* brought down by rivers, which, when spread out to any extent, form what is called alluvial land. The word is derived from the Latin verb *alluere,* signifying "to wash upon," as the sea does upon the coasts.

162. The richest alluvial soils are to be found near the junction of large sluggish rivers with the sea, or where they meet in the valleys through which they pass; and the soil is most varied and heterogeneous in the composition of its parts, when these are in minute divisions and intimately blended together. The finest natural soils are thus formed of numberless thin layers of mud by the overflowing of rivers, and left to dry till the next overflowing brings a fresh supply.†

163. Alluvial soils partake of the nature of the earth from which the waters descend, or over which they spread. They may be formed of a

* Journal of the Royal Agricultural Society. † Morton on Soils.

"Imperial Rome, in the full height
Of elegance and taste, by Greece refin'd,
In ancient times, the sacred plough employ'd
The kings and awful fathers of mankind:"—THOMPSON.

clay mud, or of a *fine sand* or *silt*, or of a mixture of *both*, and the layers of these two may alternate according as winds vary and sea currents set in. Clay is more easily disintegrated than any other mineral, and, therefore, always occurs abundantly in every alluvial soil. Marly, and all the newer calcareous rocks, as the oolites and chalk, are easily washed down by the rains and carried off by rivers. Sandstone and trap-rock, containing clay and lime; those granites, also, whose felspar contains the alkaline silicates in abundance, are easily decomposed by the rain-water and other atmospheric agents, and all their finer ingredients are carried by the streams and rivers to the great deposits near the sea. Alluvial soils thus necessarily consist of minute or impalpable particles of a great variety of minerals; for though the predominating earth may in some be clay, in others lime, and in some sand, yet, derived as they are from all the geological formations which the river and its tributaries have traversed, they cannot fail of containing in due proportion every ordinary ingredient.*

164. *How may alluvial soils be improved?*

Alluvial soils are *the most fertile of all natural deposits*, and require a treatment by which their fertility may be *diminished*, rather than *increased*, together with protection from *floods*, to which they are naturally liable. The treatment of them must also be modified according to their nature. Alluvial soils are of two kinds, one derived from the sediment of *fresh*, the other of *salt water*. They will generally bear crop after crop with little or no addition of manure, and with a very slight cultivation.

165. It is in the alluvial soils principally that an accurate *analysis* is useful, because the proportion of their constituent parts varies in innumerable degrees. It may be laid down as a general rule that the most fertile of these soils are those in which the primitive earths are nearly in equal proportions, silica being the most abundant, with about 10 per cent. of organic matter; a greater proportion of the latter would form too loose and spongy a soil to bear good crops of corn, especially of

* Morton's Cyclopædia.

"The Farmer's life displays in every part
A moral lesson to the sensual heart.
Though in the lap of plenty, thoughtful still,
He looks beyond the present good or ill;"—BLOOMFIELD.

wheat. But 4 per cent. of humus, with a good mixture of earths, and some phosphate of lime from the decomposition of bones and marine shells, produce a very good cheap soil. The rich warp-lands along the Humber are artificial alluvial soils, and although they contain but a small proportion of humus, are highly fertile after their first deposition; but it is observed that they gradually become more tenacious and difficult of culture as this humus is carried off by the crops, and that it is soon necessary to add animal and vegetable manures to supply the deficiency.

166. Lands possessing alluvial soils may be protected from flooding by *embanking* and *draining*; and low lands of a sterile nature lying in the neighbourhood of the sea, and of muddy rivers, may be rendered more or less fertile by a system of periodical irrigation, called "WARPING." Warp, or sea-ooze, abounds at the mouths of friths, estuaries, or arms of the sea. It is of a most enriching nature, and adds to the staple of the soil. It is used as a top-dressing in spring for crops both of grain and grass, more especially for the latter. It is an excellent material for composts, particularly for their soils. It promotes the improvement of garden soils in a manner hardly to be credited; and wheat or oats manured with sea-ooze are little subject to rust, mildew, or any other disorder.*

167. It takes some time before any corn will grow on the new warp. At first it looks like barren mud; but it soon dries to a better texture, and ultimately produces very extraordinary crops. If its fertility decrease, and its surface is still below the level of high water, a slight warping, like the inundations of the Nile, immediately restores the fertility. What is curious, is the almost total absence of organic matter in the warp-soils, or, rather, its intimate combination with the earths, so that it cannot be readily separated from them. It is like neither clay, nor sand, but something between the two, soft to the touch, but not hardening into lumps when dry; neither very porous, nor very retentive of moisture. The principal earth is silica, in a very fine state. It generally contains a portion of calcareous matter, probably from shells. It produces beans, oats, potatoes, and wheat in abundance, without any manure. It is admirably adapted to the growth of flax, especially when the warp is of good depth.

* Sir John Sinclair.

[illegible]

> "The pasture, and the food of plants,
> First let the young agricolist be taught:
> Then how to sow, and raise the embryo seeds
> Of every different species."—Dodsley.

168. The fertility of warped land naturally leads to the conclusion that silica, in a very comminuted state, becomes best adapted for the roots of plants to shoot in, and to supply them regularly with the moisture necessary to their vegetation, *that their chief nourishment is derived from the atmosphere*, since very little organic matter can be detected in warp, and few mineral substances besides earths.*

169. Undertakings of this nature are generally of considerable magnitude, and require large capital. The land to be warped must be banked round against the river. The banks are made of the earth taken on the spot from the land: they must slope six feet, that is, three feet on each side of the top or crown of the bank, for every foot perpendicular of rise: their top or crown is broader or narrower, according to the impetuosity of the tide and the weight and quantity of water; and it extends from two to twelve feet: their height is regulated by the height to which the spring tides flow, so as to exclude or let them in at pleasure. In these banks there are more or fewer openings, according to the size of the ground to be warped, and to the choice of the occupier; but in general they have only two sluices, one called the *flood-gate*, to admit; the other called the *clough*, to let off the water gently; these are enough for ten or fifteen acres. When the spring tide begins to ebb, the flood-gate is opened to admit the tide, the clough having been previously shut by the weight of the water brought up the river by the flow of the tide. As the tide ebbs down the river, the weight or pressure of water being taken from the outside of the clough next the river, the tide water that has been previously admitted by the flood-gate opens the clough again, and discharges itself slowly but completely through it. The cloughs are walled on each side, and so constructed as to let the water run off, between the ebb of the tide admitted and the flow of the next; and to this point particular attention is paid. The flood-gates are placed so high as only to let in the spring tides when opened. They are placed above the level of the common tides.

170. Willows are also occasionally planted on the fronts of the banks, to break the force of the tides, and defend the banks by raising the front of them with warp thus collected and accumulated; but these willows must never be planted on the banks, as they would destroy them by giving the winds power to shake them.†

* Penny Cyclopædia: Art. "Warping."

† Lord Hawke.

"Ye fostering breezes, blow!
Ye softening dews, ye tender showers, descend!
And temper all, thou world-reviving Sun,
Into the perfect year!"—THOMSON.

171. Warp leaves one-eighth of an inch every tide on an average; and these layers do not mix in an uniform mass. but remain in distinct layers.

172. If only one sluice, then only every other tide can be used, as the water must run perfectly off, that the surface may incrust; and if the canal be not empty, the tide has not the effect.

173. As a new soil is created by this practice, it is of little consequence what the original nature of the land may be, almost all kinds being improved by it. But at the same time it may be the most beneficial in such light soils as are very open and porous, and such stiff ones as are defective in calcareous matter, and which require substances of this kind to render them less tenacious. Land, when once well warped, will continue for a vast length of time in a good state of fertility; but still, it is suggested by some experienced warpers as a better practice, to apply a small portion of warp whenever the land is in a state of fallow, which will be about every five or six years, as by this means the farmer will be more secure of having good crops. The depth to which the lands are covered by the tides must be regulated according to their levels, and the height of the tides in the rivers from which they proceed. It may be admitted to the height of three or four, or more feet; but the deposit of sediment is in some measure proportionate to the height of the water, though the same effects may be obtained from much smaller quantities of water by continuing the process a great number of tides.*

174. *Example of Improvement of an Alluvial Soil.*—The late Lord Kames, on becoming proprietor of the estate of Blair Drummond, in the county of Perth, began the improvement of a large tract of worthless land. In this case, a good alluvial clay soil had become completely overgrown with moss. Instead, therefore, of attempting to improve the moss surface, it was floated off piecemeal into the neighbouring sea, the supply of water required for this purpose being obtained from an adjacent river. The water being conveyed through the moss in channels, successive layers of peat were dug, thrown in, and washed away. The channels were shifted, as occasion required, until the whole inert mass was removed. A thin stratum next the clay was then burnt, and the ashes used as manure. An immense extent

* Johnson's "Farmer's Encyclopædia."

of moss was got rid of, and an extensive tract of country, where formerly only a few snipes and muir-fowl could find subsistence, was converted into a rich and fertile course of alluvial soil, worth from £3 to £5 an acre—15 to 25 dollars.

175. *Example of Improvement by Warping.*—In 1821, Mr. Ralphe Creyke undertook to reclaim a large area of peat-moss in Yorkshire, by the system of warping. He resolved to warp from the river Ouse some 1,600 acres. The undertaking was commenced in the latter part of 1821, and in the following season, 429 out of the 1,600 acres were covered with a deposited soil to the depth of 3 feet. In 1823, this land was sown with oats and grain seeds, and on the fourth year bore an excellent crop of wheat. By this time the other two compartments, respectively consisting of 500 and 671 acres, were completed, and in a state of preparation for their first crop of oats, &c. In this case, so great was the improvement, that the land, which before warping was entirely unproductive and yielded no rent whatever, in the course of four years produced abundant crops, and readily let for 35s. per acre.*

176. *What is the origin of marshy soils?*

Marshy soils result from the low situation of lands, causing them to *receive and retain water* from the surrounding country ; or from the presence of *internal springs*, without any suitable channels of escape. The lowest for the most part in the scale of fertility, of these wet grounds, and yet of great importance in the elevated districts where they abound, are those which consist of a thick bed of peaty matter. These are usually termed *bogs*, and the produce consists chiefly of rushes, as the sharp-flowered jointed rush, and others.

177. *How may marshy soils be improved?*

If the humidity of the soil is caused by the stagnation of water from the surrounding hills, the first thing to be

* Journal of the Royal Agricultural Society.

"Thy weedy fallows let the plough pervade,
Till on the top the inverted roots are laid,
There left to wither in the noontide ray,
Or by the spiky harrow cleared away."—SCOTT.

ascertained is whether or not a canal, the bottom of which shall be on a level with the marsh, can be dug on the declivity of the hill, to prevent the water from over-running the soil.

178. *If the marsh is surrounded with hills*, the remedy consists in finding an outlet for the water through one of the inferior strata of the soil; but success in this will depend upon whether the marsh is above the level of the nearest river or pond.

179. *If the dampness arises from springs*, the essential point is to discover the level or height at which these break out. Sometimes they show themselves at the edge of the marsh, in a position rather higher than the spongy earth. When in this position, they may be carried off by a drain, or by holes bored in the soil with an auger, and the marsh thus dried without the necessity of cutting through its whole extent. But in general the only way of conveying the water to some brook or reservoir is by excavating a canal of some size along the bottom of the marsh.

180. *If the springs rise from the bottom of the marsh*, there is nothing that can be done but to form a large drain or canal for carrying off the water across the marsh.

181. *If the humidity is caused by some reservoir of water*, either in the vicinity or some distance off, the water finding its way through the permeable soil, or by means of the veins of the strata, the point to be ascertained is whether or not it is practicable to carry off the water through some drain, that shall intercept the communication between the morass and the reservoir.*

* Thäer's "Principles of Agriculture."

> "The land with daily care
> Is exercised, and with an iron war
> Of rakes and harrows the proud foe's expelled
> And birds with clamours frightened from the field."—DRYDEN.

182. The draining of marshes, fens, bogs, &c., usually requires operations upon a large scale, which cannot be conducted without the aid of engineering skill.

183. *Example of Improvement.*—I have been several years in the occupation of 300 acres of marsh land, in the county of Kent, more or less subject to a coarse grass we call sword grass, with the ditch bank 2½ feet above the level of the land, and 3 feet above the water. To improve this grass, or get stock to eat it, I have tried salt, lime, and chalk; but, as none of these answered to my satisfaction, in the year 1831 I commenced, on a marsh of 4 acres, by first cutting the ant-hills, and then setting a number of men to harrow the ditch-bank into the middle of the marsh, finding I had sufficient mould to cover it all over about 1½ inches thick. I then sowed it with *Tartarian oats*, about 5 bushels per acre, in the month of February, well harrowing the ground with an ox-harrow, having the large lumps chopped; then, as early as possible after the oats were up, rolling them twice or three times, and letting the oats and grass grow up together till harvest. They were ready to cut at least a week before the up-land corn. I have them reaped sufficiently low to collect the corn; then set the scythe to cut, between the shocks, the grass and stubble, which is nearly knee high. The latter I cart into a stack as soon as I can get it dry, adding some salt to every load. The oats I frequently bring home to a meadow to harvest, as it not only clears the marsh for stock, but finds advantageous work for my horses. In stacking the oats, I have a mawn basket drawn up the middle; they being nearly all corn, with so little straw, are apt to heat. After I had finished a second marsh of 8 acres, in 1832, I requested my worthy landlord's attention to this improvement of his estate; he immediately agreed to pay half the manual labour during my lease, if I harrowed at least 240 rods per annum. This formed part of my new lease then; and I stood under agreement to finish those that had not been done. The result was as follows:—

184. In 1831 I covered the before-stated 4 acres, cleared 322 quarters of oats, and cut at least a load of brushings; 1832, 8 acres; 1833, 14 acres (this marsh I chalked about three years before); 1835, 19 acres (in this marsh I lined 120 rods of bark during the summer with unslacked lime, and in the winter it might have been moved with a barn scuppet; nothing extra good in this crop; but I feel assured

"O faithful Nature, dictator of the laws
Which govern and support the mighty frame
Of universal being."—AKENSIDE.

the marsh is improved more in proportion than those without lime). In 1836, 22 acres; 1837, 16 acres; 1838, 14 acres; 1839, 15 acres, earthed, but not sown with oats. I do not think the marsh covered itself so soon with grass, there being no oats to keep the sun off, or seeds to shatter. In 1840, 16 acres; 1841, 17 acres, with more than 10 quarters of oats per acre. In 1842, 22 acres; and I have now a crop growing with at least 9 quarters per acre. I use about 60 acres of marsh land belonging to an adjoining estate. None of these banks were removed; and one year, after lambing, I lost more stock on these 60 acres than on all those that had the banks removed.

185. Those marshes that have been thus treated a few years, I consider very much improved; they keep more stock, and yield grass of a much better quality, much less sword grass, no drinkings required for the stock, and if a lamb falls in, it can walk out on either side. As to appearance, it is beyond me to describe the improvement.*

186. *What is the origin of loamy soils?*

Loamy soils are produced by *similar causes to those of clay*; but they are more fertile, because they contain decomposed vegetable matter, or *humus*. Loam consists chiefly of woody fibre in a state of decay, which, as it progresses, acquires a black-brown colour, and then becomes mould.

187. Loam is a native clay, mixed with quartz, sand, and occasionally with some carbonate of lime, or a soil compounded of various earths, of which the chief are silicious sand, clay, and carbonate of lime, or chalk, the clay predominating. With these substances the decomposed vegetable matter is intermixed.

188. Woody fibre in a state of decay is the substance called *humus*. Transformations of existing compounds are constantly taking place during the whole life of a plant, in consequence of which, and as the result of these transformations, there are produced gaseous matters which are excreted by the leaves and blossoms; solid excrements deposited in the bark, and fluid soluble substances, which are eliminated

* John Murton, Cooling Castle, Kent.

"Plant behind, plant aspiring, in the van
The dwarfish in the rear retired, but still
Sublime above the rest, the statelier stand."—COWPER.

by the roots. Such secretions are most abundant immediately before the formation and during the continuance of the blossoms; they diminish after the development of the fruit. Substances containing a large proportion of carbon are excreted by the roots, and absorbed by the soil. The soluble matter thus acquired by the soil is still capable of decay and putrefaction; and by undergoing these processes furnishes renewed sources of nutrition to another generation of plants, and it becomes *humus.* The leaves of trees which fall in the forest in autumn, and the old roots of grass in the meadow, are likewise converted into humus by the same influence; a soil receives more carbon in this form than its decaying humus had lost as carbonic acid. *Humus does not nourish the plants by being taken up and assimilated in its unaltered state, but by presenting a slow and lasting source of carbonic acid, which is absorbed by the roots,* and is the principal nutriment of young plants at a time when, being destitute of leaves, they are unable to extract food from the atmosphere.*

189. The decomposition of woody matter by *burning* and *decay*, and the similarity of the result under each process, may be thus illustrated. As *wood*, which is only *partially consumed*, can be consumed *still further*, so also *humus* is gradually *further decayed or decomposed;* and in most cases, after *complete combustion* or *decay*, there is finally left only a small quantity of the *ashes*, which the wood has absorbed from the earth during its growth. The result is thus:—

From Burning.		*From Decay.*	
From the *wood* in the first instance . . .	Water (much), carbonic acid gas, half-burnt wood.	From the *wood in* the first instance . . .	Water(much), carbonic acid gas, *humus*, or *mould.*
From the *half-burnt* wood, in the second instance . . .	Water (little), carbonic acid gas;	From the *humus*, in the second instance . . .	Water (little), carbonic acid gas;
There remain—*ashes.*		There remain—*ashes.*	

190. The *oxygen* and *hydrogen* of the wood or humus unite to *form water.*†

* Liebig. † Stockhardt's "Chemistry."

"For every leaf that twirls, the breeze,
May useful hints and lessons give;
The falling leaves and fading trees
Will teach and caution us to live."—CLARE.

191. *How may loamy soils be improved?*

The treatment of loamy soils depends materially upon their nature; whether they are sandy, gravelly, clayey, calcareous, peaty, or mixed in those proportions which are best for fertilization, as in the hazel, or brown loam.

192. In the climate of England, the soil which is generally preferred for cultivation is a loam, rather light than heavy; at least half of which is *silicious sand*, one-third *clay*, and the rest *chalk*. Such a soil is called a good loam; it is land which will produce, almost everything which is usually cultivated on sands or clays; it is not *too stiff* for carrots and turnips, and not *too loose* for wheat and beans. It is of most easy cultivation at all times of the year, provided the subsoil be sound, and not too retentive of water. It requires only to be occasionally recruited with manure, to restore to it the humus which vegetation has consumed, and to be kept free from the weeds which naturally spring up in all fertile soils.

193. All attempts to improve the nature of a soil *should have for their object the bringing it to a state of loam*, by the addition of those substances which are deficient. If there is too much clay, chalk and sand may be added, or a portion of the clay may be calcined by burning, in order to destroy its attraction for water, and thus act the part of sand in forming the loam. Limestone, or calcareous sand and gravel, are still more efficacious for this purpose; they not only *correct too great porosity*, or too great *tenacity*, but also act *chemically* on the organic matter in the soil, *rendering the humus soluble*, and fit to be taken up by the roots of plants. If there is too much sand, marl composed of clay and chalk is the remedy. Good loams require much less tillage than stiffer soils, and will bear more stirring to clean them than sands. Hence they are cultivated more economically, and more easily kept free from useless weeds; while the produce is more certain and abundant. They can be impregnated to a higher degree with enriching manures, without danger of root-fallen crops, or of too great an abundance of straw at the expense of the grain. For artificial meadows they are eminently proper: all the grasses grow well in good loams, when they are on a dry or well-drained subsoil, which is an indispensable condition in all good land. Sheep and cattle can be depastured on them during

> "Joyous, the impatient husbandman perceives
> Relenting Nature, and his lusty steers
> Drives from their stalls, to where the well-used plough
> Lies in the furrow, loosen'd from the frost."—THOMSON.

the whole year, except when there is snow on the ground. If there should be means of irrigation, no soil is better suited to it than a light loam on a bed of gravel; or even if the subsoil is clay, provided sufficient under-draining prevent the water from stagnating between the soil and subsoil, which, as practical men very properly express it, would *poison* any land.

194. A loamy soil requires *less dung to keep it in heart* than either clay or sand; for while it is favourable to the process by which organic matter buried deep in the soil is converted into insoluble humus, it also permits that part of it which is nearer to the surface to attract oxygen from the air, and thus it is converted into a *soluble extract, which is to the roots of plants what the milk of animals is to their young—a ready-prepared food easily converted into vegetable juices.*

195. *Why are there two distinct well-defined classes of substances in soils?*

Because every soil consists of two grand divisions of elements: the ORGANIC *and the* INORGANIC. The *inorganic* are WHOLLY MINERAL, they are the products of chemical and mechanical action upon the metallic and mineral elements of rocks. They existed, and have been geographically diffused, independently of plants or animals. Life has not created them out of simple elements.

196. The *organic* are the *product of substances* ONCE ENDOWED WITH LIFE. This power influences the elements, recombines them in forms, so essentially connected with life, that they are, with few exceptions, *produced only by a living process.* They are the produce of *living organs*, hence termed ORGANIC.

197. The number of elements in the *inorganic* parts of soil is TWELVE: *oxygen, sulphur, phosphorus, carbon, silica;* and

* Penny Cyclopædia: Art. "Loam."

"In Rome's poor age,
When both her Kings and Consuls held the plough."—JONSON.

the metals, *potash*, *sodia*, *calcium*, *alumina*, *magnesia*, *iron*, and *manganese*.

198. The number of elements in the *organic* parts of soil, does not exceed FOUR; *oxygen*, *hydrogen*, *carbon*, and *nitrogen*.

199. The mineral elements of soil *become part of plants*. Under the influence of the mysterious principle of *life*, they no longer obey the merely chemical laws, but become *parts of a living structure*. Life modifies chemical laws, and *converts inorganic matter into organic*.

200. Every plant does not, nor does every part of the same plant contain the same elements; but every part of the same plant, at the same age, probably contains the same elements, united in definite proportions. Whenever plants die, their elements are again subject to the laws of change, and during the decay of vegetables, they return to the earth, not only those substances which the plants had taken from the soil, but also those which have been elaborated by their living structures, under the influence of life. The former are silicates and salts, or the *inorganic* elements; the latter are the *organic* parts of the soils.

201. The GREAT DIFFERENCE between these two divisions of the elements of soils, is THIS, *that while the inorganic are simple combinations of* TWO *elementary substances, the organic are combinations of* THREE *or* FOUR *elements, but* NEVER LESS *than* THREE. These are *variously combined.* They form the great body of vegetable products; the mere *abstraction of a part of one* of their elements forms a NEW PRODUCT.*

202. *The fertility of a soil* is dependent on OTHER things *besides its chemical composition.* We must consider that the office it performs is TWOFOLD, namely, to *retain the plant firmly in the position most favourable to its growth*, and to *supply a certain amount of food*: hence *mechanical texture* becomes a matter of great importance; it

* Dr. S. L. Dana.

> "The crowded roots demand enlargement now,
> And transplantation in an ampler space:
> Indulged in what they wish, they soon supply
> Large foliage."—COWPER.

must be *firm enough* to afford the proper degree of support, and at the same time *loose enough* to allow the delicate fibres of the rootlets to extend themselves, and also access of air to take place, without which the plant cannot live; it must be of such a texture as to *retain for a considerable period the water which falls on it*, and at the same time porous enough to *suffer the excess to drain away*, otherwise the roots of the plant will rot. It is for these reasons that the nature of the solid *substratum* at some depth beneath the soil must be borne in mind; these, and many other things, such, for example, as the *condition of the surface with respect to its absorbent power for heat*, all tend greatly to complicate the subject, and render decisions concerning the comparative value of different lands founded on *merely chemical* evidence exceedingly prone to error.*

203. *What becomes of the elements of soil under the operations of agriculture?*

The course of transmutation may be thus illustrated with tolerable accuracy. *Alumina* stops *in the soil; silica*, except in exceedingly minute quantities, goes *with the plant;* the other ten *pass from the soil into the plant;* then *from the plant into the animal;* and finally *back into the soil.* From this it will be seen that when we *expend crops on the farm*, we *return to the soil all we took from it*, and *as much more as the growing plants draw from the air*, which is nearly all their organic matter.

204. In this way a farm should be constantly GAINING IN FERTILITY; for, on the supposition that *we sell nothing* from the farm, we keep all the inorganic parts of the soil at home, and by means of growing plants we are all the while *gathering inorganic matter from the air, and incorporating it with the soil;* so that the soil, treated thus, would remain equally rich in the organic (mineral) parts, and be *growing every year richer in the organic parts.*

* Dr. Fownes.

"The changeful year
In all its due successions to my sight
Presents but varied beauties."—SOUTHEY.

205. It will be seen, also, that if *we sell off crops*, or anything that is made from crops, as *beef*, *pork*, *butter*, *cheese*, the soil *must be from that time becoming poorer in the inorganic ingredients, unless we procure fertilizers from off the farm and substitute them for those which we send away*; for when we sell any product of the farm, WE SELL A PART OF THE SOIL; not enough in a single pound of butter to diminish sensibly the quantity left, *but enough in a century*, IN ALL THE BUTTER that may be sold from cows fed on a single pasture, TO LEAVE THAT PASTURE ENTIRELY DESTITUTE OF CERTAIN INGREDIENTS, *without which good butter cannot be made.*

206. So, if the *hay* from a mowing was to be *sold off for many years*, and *nothing returned*, certain ingredients of the soil would become so exhausted, that *little or no more hay could be grown on that soil*; or if the *corn*, *wheat*, or *rye* were to be *sold from a soil*, the *result would be the same.* If a soil were eminently GOOD, it would resist bad treatment *a long time*, but sooner or later it would be EXHAUSTED. THE FARMER WHO SHOULD HAVE SOLD ALL HIS CROPS FOR A LONG TIME, AND PUT NOTHING BACK, WOULD FIND THAT HE HAD SOLD HIS FARM ALSO—SOLD IT PIECEMEAL.*

207. *What is the great essential principle to be sought for in manure?*

It may be regarded, as a great law of nature, that *substances strengthen vegetation mainly by their contents* of *nitrogen.* This law sheds at once an harmonious light over the scattered facts which the unlettered husbandman has learned while still groping in the darkness of practice.

* J. A. Nash.

"Fair-handed Spring unbosoms every grace;
Throws out the snowdrop and the crocus first,
The daisy, primrose, violet darkly blue."—THOMSON.

208. If we look at the practice of manuring only, we find the most dissimilar substances applied to the soil—*sprats* or *sticklebacks* here; *woollen rags*, or *shoddy*, or *horn-shavings* there; *sea-weed* in another place; *rape-cake* elsewhere. *All these matters, however, agree in containing undeveloped* NITROGEN.

209. Again, *lupines*, sown for the purpose, are in some countries ploughed in as manure, as are the remains of the clover crop, both also containing *nitrogen undeveloped.*

210. In dung, and in liquid manure, the nitrogenous matter is *partly* combined with *hydrogen*, and has thus become *ammonia*. In other manures, as *soot* and *gas-water*, the pungent smell shows the *full* development of *ammonia.*

211. Again, *nitrogen* may combine not only with *hydrogen* to form an alkali, *ammonia*, but with *oxygen*, also, to form an *acid*. That acid, in whatever combination, whether with *potash*, *soda*, or *lime*, is equally active; nay, the consuming liquid itself is able to nourish the tender herbage of the green lawn. This same law explains, moreover, not fertilizing substances alone, but the fertility of the soil itself, throughout many wide tracts. Not only are the plains of Hindostan made fruitful by their native saltpetre, but the famous Tchornoi Zem, or black earth, which, over wide tracts around Tamboff bears wheat crops in endless succession, and will not endure to be drained with dung, has been found by late analysis to be charged with nitrogenous matter, the remains of living organisms. Nay, when poets tell us that battle-fields are rendered fertile for ages by patriot blood, we now understand scientifically this mournful memorial of human slaughter. * * * The general law is established as to nitrogenous matters: but *whether they act upon plants in two forms*, AMMONIA and NITRIC ACID, or *whether, by some secret of nature, either of these forms is transmuted into the other before it serves the purpose of vegetable nutrition, is a question reserved for the future decision of agricultural chemists.*

* Lord Ashburton, President of the Royal Agricultural Society.

'The seed selected wisely, plump and smooth
And glossy, he commits to pots of size
Diminutive, well filled, with well prepared
And fruitful soil."—COWPER.

212. *Why may the nature of a soil be generally inferred from the plants that grow spontaneously upon it?*

Because plants have different *habits*, and their presence, or the degree in which they thrive in any particular locality, indicates the abundance or scarcity of the subsistence upon which they depend. The plentiful growth of the *corn or field thistle* indicates a *rich and productive soil*; the *butter-bur* a *clayey soil*; the *colt's foot*, *black medick*, and the *bramble*, a *marly soil*; the *chickweed*, *sow thistle*, *charlock*, &c., grow on *soft tenacious lands*; while the *wild radish* grows on *dry* and *poor lands*.*

213. The best *natural soils* are those of which the materials have been derived from *different strata*, or layers of earth, which have been *minutely divided* by *air* and *water*, and are *intimately* blended together: and, in *improving soils artificially*, THE FARMER CANNOT DO BETTER THAN IMITATE THE PROCESSES OF NATURE: *the materials necessary for the purpose are seldom far distant.*. *Coarse sand* is often *found immediately on chalk*; and beds of *sand and gravel* are common *below clay*. The labour of improving the texture or constitution of the soil is repaid by a great permanent advantage; LESS MANURE IS REQUIRED AND FERTILITY INSURED: and CAPITAL laid out in this way SECURES FOR EVER THE PRODUCTIVENESS OF THE LAND.

214. *In ascertaining the composition of sterile soils* with a view to their improvement, any particular ingredient which is the cause of their unproductiveness, should be carefully attended to; if possible, *they should be compared with fertile soils in the same neighbourhood, and in similar situations*, as THE DIFFERENCE IN COMPOSITION may, in many cases, INDICATE THE MOST PROPER METHODS OF IMPROVEMENT.

215. If on washing a sterile soil it is found to contain the *salts of iron*, or any *acid* matter, it may be ameliorated by the application of *quick lime*.

* Thäer's Agriculture.

"Disposed into congenial soils
Stands each attractive plant, and sucks and swells
The juicy tide—a twining mass of tubes."—THOMSON.

216. If there be an excess of *chalky matter* in the soil, it may be improved by the application of *sand* or *clay*.

217. Soils too abundant in *sand*, may be benefited by the use of *clay*, or *marl*, or *vegetable matter*.

218. *A deficiency of animal or vegetable matter* must be supplied by *manure*. An *excess of vegetable matter* is to be removed by *burning*, or to be remedied by the application of *earthy materials*.

219. *The improvement of peats, bogs*, or *marsh lands*, must be preceded by *draining;* stagnant water being injurious to all the nutritive classes of plants. *Soft black peats*, when drained, are often made productive by the mere application of *sand* or *clay* as a top dressing.

220. *When peats are acid*, or contain *salts of iron, lime*, or *chalky matter* is absolutely necessary to bring them into cultivation. *When they abound in the branches and the roots of trees*, or when *their surface consists of living vegetables*, the wood or the vegetables must either be *carried off*, or be *destroyed by burning*. In the last case, their *ashes* afford *earthy ingredients* fitted to *improve the texture of the peat.**

221. *Why are soils allowed to lie fallow?*

Because, by fallowing, the poorer soil is *exposed to the action of the air;* and there is then absorbed by the soil, a considerable portion of *ammonia, carbonic acid*, &c., and from water the soil has gathered *sulphates* and other materials essential for the growth of plants. When the crop follows, the plants are not only enabled to *feed themselves by their* LEAVES, but are *able to absorb by their* ROOTS *the nutritive matter which has been accumulating for them.* The process of fallowing is neither more nor less than one of those practical plans by which you *place in the soil an additional quantity of the materials which are required for an increased growth*

* Sir Humphry Davy.

"Yes, lovely flower, I find in thee
Wild sweetness which no words express,
And charms in thy simplicity
That dwell not in the pride of dress."—LANGHORNE.

of vegetables. It is, in fact, a system of MANURING FROM THE AIR.*

222. *Why does the "rotation of crops" supersede the necessity for "fallowing?"*

Because *different plants operate in various ways upon the soil. It* is owing to the difference of the food necessary for the growth of plants, and which must be furnished by the soil, that different kinds of plants exert mutual injury when growing together, and that others, on the contrary, grow together with great luxuriance.

223. Two plants *of the same kind* growing in close vicinity must prove prejudicial to each other, when they find in the soil, or in the atmosphere surrounding them, *less of the means of nourishment than they require* for their perfect development. *There is no plant more injurious to wheat, than wheat itself; none more hurtful to the potatoe than another potatoe.* Hence we find that the cultivated plants *on the borders of a field* are *much more luxuriant,* not only in strength, but in the number and richness of their seeds or fibres, *than plants* growing in the middle of the same field.†

224. We also find that a plant which accidentally finds its way among a crop of a different or an opposite nature grows with a remarkable luxuriance, its own peculiar food being abundant.

225. The food of plants *derived from the air* being *more abundant than that in the soil,* the necessity for ROTATION is chiefly dictated by *the exhaustion of the essential elements of soils.*

226. The principles upon which the ROTATION SYSTEM is based are as follow:—

227. First.—*Every plant removes from the soil a certain quantity of soluble materials.*

* Nesbit's "Agricultural Chemistry." † Liebig.

> "Then spring the living herbs profusely wild,
> O'er all the deep green earth, beyond the power
> Of botanist to number up their tribes."—THOMSON.

228. Second.—*All varieties of plants do not take from the soil the same quantity of materials.*

229. Third.—*All varieties of plants do not extract from the soil the same kind of materials.*

230. Fourth.—*Each kind of plant differently affects the growth of weeds.**

231. If a *grain of wheat* and a *pea* be grown *in the same soil,* the former will obtain for itself all the *silex,* or flinty matter, which the water can dissolve; and it is the deposition of this in the stem which gives to all the grasses so much firmness. On the other hand, *the pea will reject this,* and WILL TAKE UP *whatever compounds of lime the water of the soil contains, these* being REJECTED BY THE WHEAT.†

232. The inferences are :—

233. I.—That plants which require *chiefly* the same kind of materials for their support, should NOT be grown *in succession.*

234. II.—That as the effects which different crops produce upon the fertility of the soil are influenced by the purpose for which they are grown,—plants alternated for the sake of their SEEDS, as *wheat, barley, oats, flax,* &c., should be made to *alternate* with those which are cultivated for their ROOTS, FOLIAGE, or FIBRE, as *turnips, clover, beet,* &c., and also *hemp* and *flax,* when *the seeds are not allowed to ripen.*

235. III.—*That the greatest possible interval* should be introduced in the rotation between plants of the same kind, by the growth of *as great a variety of crops as the climate of the country will allow,* thus, instead of the farmer confining himself to *wheat, barley, oats, turnips, potatoes,* and *clover,* HE SHOULD CULTIVATE *beans, peas, vetches, mangel wurzel, carrots, parsnips, beet, flax, hemp,* &c., and should make himself acquainted with *the best order of succession in which these may be grown.*‡

236. The problem as to *the best succession of crops* is difficult of solution, because experience affords so many contradictory answers, which, without doubt, arise from the *variations* which exist in *soils* and *climates* of different localities and countries.

* Cameron's "Chemistry of Agriculture."
† Dr. Carpenter's "Vegetable Physiology."
‡ Professor Hodges.

"Through hedge-row leaves in drifted heaps
Left by the stormy blast,
The little hopeful blossom peeps,
And tells of winter past."—CLARE.

237. It is contended by some that *each plant does not require peculiar elements for its nutrition*, but that its own organs digest and assimilate to it those juices which they extract from all those component parts of the soil which are *destined for the nutrition of plants in general*. Vegetables whose properties are the most opposite—plants the most corrosive and venomous, as well as those which are most beautiful and useful—those the most opposite in variety and contradictory in nature—will be found growing on the same soil and flourishing together. The *constituent parts* of all organic substances are *carbon*, *oxygen*, and *hydrogen*, with a small portion of *nitrogen*. These parts are to be met with in every *fertile* soil, even if they are not imbibed directly from the atmosphere.

238. But theory alone is quite sufficient clearly to demonstrate the necessity of ROTATION under either hypothesis; BECAUSE, although plants subsist upon similar elements, they *combine these substances in very different degrees*. It is possible that the roots or suckers of all kinds of plants possess *a sensibility and a power of choice, which enables them to imbibe and appropriate to themselves the exact proportion of each of these substances which nature leads them to require for their support*. But in order that they may succeed in accomplishing this purpose, it is necessary that they should be enabled to *meet with the proper proportions and combinations* of these substances within their own immediate sphere. If the proportion *does not exist*, or if some of these substances are present, but *not in sufficient quantity*, or in *that degree of combination which the plant requires*, then its growth will be slower, and it will not thrive so well. In a soil which, although not entirely without some of these substances, yet does not contain a sufficient quantity of it, the plant must put forth its roots in every direction to seek and absorb that which is absolutely necessary for its nourishment. It is not improbable that the soil may contain *too great a proportion* of some one of these necessary substances, and that the plant, *being suffocated by the superabundance of it*, and the scarcity or total absence of all the others, may not thrive.*

239. The following list of vegetable products, of each class of which there are *many kinds and qualities*, will serve to show the necessity of studying the nature of plants and the soil employed in their production.

* Thäer's "Principles of Agriculture."

'How blest delicious scene! the eye that greets
Thy open beauties, or thy lone retreats,
Beholds the unwearied sweep of wood that scales
Thy cliffs!"—WORDSWORTH.

They are:—*gums, sugar, starch, gluten, albumen, fibrin, tannin, colouring matter, bitters, narcotics, oils, tallow, wax, resins, gum-resins, balsams, camphor, caoutchouc, cork, sap, fermentive juices, acids, alkalies, phosphates, carbonates, wood, earths,* and *metallic oxides.*

240. But *rotation* is not rendered essential *merely* on account of the *exhausting* effects which particular plants have upon the soil. Every plant gives out more or less EXCRETORY matter. The *excretion* of every organic body is *prejudicial to the health of that body, but may be the means of subsistence to organizations of a different nature.* As each plant has peculiar excretory matters, which it constantly deposits in the soil—and as these matters are found to be particularly noxious to other plants *of the same species*—it is obvious that *until such excretory matters are removed from the earth by other plants, or by the gradual effects of decomposition, the same crop cannot prosper in the soil.* In support of this doctrine is adduced the well-known fact, that the excretory matters deposited or diffused through the water in which bulbs or other roots have been cultivated, will not well support other bulbs; yet such impure water is found to be more grateful than clean water to vegetables of another species.*

241. This *theory of excretion*, and the *deterioration of soils thereby*, was upheld by De Candolle, who asserted that *the roots of all plants give out, or excrete, certain substances peculiar to themselves.*

242. These substances are *unfavourable to the growth of the plants from the roots of which they are thrown off, but are capable of promoting the growth of plants of other species; thus the excretions of one species are poisonous to all the members of that species, but nutritive to other kinds.*†

243. Dr. Daubeny instituted a series of experiments to ascertain whether the same crops grown permanently on a given soil, fail *in consequence of noxious excretions*, or from the *exhaustion of the soil.* He neither confirmed nor refuted the theory of De Candolle, but *left the problem for further investigation.* He did, however, establish the

* Johnson's "Farmer's Encyclopædia."

† De Candolle's "Vegetable Organography."—See the "Botanical Reason Why."

"How strange a scene has come to pass,
Since Summer 'gan to reign,
Spring flowers are buried in the grass,
To sleep till Spring again."—CLARE.

fact of the *exhaustion of soils,* both as regards their organic and inorganic constituents. He showed that the falling off of the crop is dependent upon a *deficiency of organic matter* proper to promote the nutrition of the plants, as well as upon *the failure of its inorganic principles;* not, indeed, that the organic matter enters, *as such,* into the constitution of the vegetable, but that *by its decomposition* it furnishes it with a *more abundant supply of carbonic acid* and *ammonia,* which supply accelerates the development of its parts, and thus at once enables it to extract more inorganic matter from the soil, and enables the soil to supply it copiously with the principles it requires. He further showed that it by no means follows, because a soil is benefited by manuring, even though that manure may, as in the case of bones, guano, &c., derive its efficacy from the phosphates it supplies, that the soil is, therefore, destitute of the ingredient in question, since *it may happen that the soil possesses abundance of it in a dormant, though not in an immediately available condition.**

244. Professor Johnston, in his "Lectures on Agricultural Chemistry and Geology," does not entirely espouse the interesting theory of De Candolle's. He says:—Though there seems reason enough for believing that the roots of plants *really do give out certain substances into the soil,* there is *no evidence that these excretions take place to the extent* which the theory of De Candolle would imply—*none of a satisfactory kind that they are noxious* to the plants from which they are excreted—[Why, then, excreted?]—and none, that *they are especially nutritive to the plants of other species.*

245. The true *general* REASON WHY (Prof. Johnston continues) a second or third crop of the same kind will not grow well, is, *not* that the soil contains *too much* of *any,* but that it contains *too little* of *one* or more kinds of matter. If, after manuring, *turnips* grow luxuriantly, it is *because the soil has been enriched by all that the crop requires.* If a healthy *barley* crop *follow the turnips,* it is *because the soil contains all the food of this new plant.* If *clover* thrive after this, it is *because it naturally requires certain other kinds of nourishment which neither of the former crops had exhausted.* If, again, luxuriant *wheat* succeeds, it is *because the soil abounds still in all that the wheat crop needs*—the failing vegetable and other matters of the

* Philosophical Transactions. Vol. 135.

> "Daisies are white upon the churchyard sod;
> Sweet tears the clouds lean down and give.
> This world is very lovely. O my God,
> I thank Thee that I live."—ALEX. SMITH.

surface *being increased and renewed by the enriching roots of the preceding clover.* And if now, *turnips* refuse to again give a fair return, it is *because you have not added to the soil a fresh supply of that manure without which they cannot thrive.* ADD THE MANURE, AND THE SAME ROTATION OF CROPS MAY AGAIN ENSUE.

246. These various theories, however, EQUALLY *support the system of* ROTATION, while *the practice of that system confirms the theories.*

247. In a work designed for circulation in wide geographical latitudes, it is impracticable to submit *courses of rotation;* but the *principles upon which they should be adopted,* may be distinctly enforced. The propriety of following any particular system of cropping, will be considerably influenced by the following circumstances:—

248. *The climate,* whether it be wet or dry, *warm* or *cold;* and the *situation,* whether *high* or *low.* Wet climates, and high situations, for instance, are rather favourable to the growth of *oats;* dry climates, and low situations to that of *barley.*

249. *The soil,* for *sand, gravel, clay, chalk, peat, alluvia,* and *loam,* have various crops *calculated for each respectively;* and *the subsoil,* on the quality of which the crops to be raised must greatly depend.

250. *The means of improvement by extra manure,* as *lime, marl, sea-weed, town dung, guano,* and the *artificial manures,* at reasonable rates; *for the rotation of crops should not be regulated by the nature of the soil alone,* BUT CONJOINED *with the specific manures that can be obtained at a moderate expense.*

251. *The state and condition of the soil,* whether it be *old* cultivated land, or *recently improved;* whether it be land that has been *cropped judiciously,* or under an *exhausting system of management;* whether it be in *good heart,* or *the reverse;* whether it be *foul* or *clean;* and lastly,

252. *The situation of a farm in regard to markets,* whether they are *near* or at a *considerable distance;* and whether they are *adapted to the sale of some articles of produce more than others.*

"Oh! while my eye the landscape views
What countless beauties are displayed,
What varied tints of nameless hues,
Shades endless melting into shade."—CLARE.

253. The following important RULES IN REGARD TO ROTATIONS are of *universal application:*—

254.—1. When any farm or district *begins to be improved*, it is necessary to *commence* with such crops *as are the most likely to produce manure.* Hence *barley* ought *to be avoided*, as it yields, when compared to other crops, *the smallest quantity of straw.*

255.—2. Two *exhausting crops* should never be attempted *in succession*, if the soil has not *acquired a considerable degree of fertility*, or does not naturally possess it, as in the case of alluvial lands.

256.—3. *Green crops* are greatly to be preferred, as, from their superior bulk, they are *more productive of manure*, and go further in *supporting live stock.* In similar soils and situations, green crops will furnish at least *one-fourth*, and in many cases *one-third* more putrescent manure, *than can be obtained from the straw of corn crops*, grown on the *same land.* After green crops, also, the *weight* and *quality* of the *next crop of corn are greatly improved*, and it *fetches a higher price in the market.*

257.—4. *The crops should be so arranged* that the LABOUR of *ploughing* for each, and of *sowing, weeding, reaping*, &c., may proceed in a *regular succession*, by which the labour of cultivation is *not too much crowded on the farmer*, at any *one season of the year*, nor any number of *extra stock rendered necessary.* All the crops produced on the farm, may thus be cultivated by *the same labourers* (with the exception of *hand-hoers* in spring and summer, and assistants during the harvest), and with *the same cattle.*

258.—5. *All forcing crops, or frequent repetitions of the same species should be* AVOIDED, as a *diminution both in the quantity and the quality of the produce* (except in rare instances) *is the consequence.* Indeed, in soils of moderate fertility, as they are commonly cultivated, *the* GREATER DISTANCE *at which* THE REPETITION *of any sort of crop can be kept*, THE BETTER IT IS LIKELY TO PROVE.

259.—6. *Those crops should be raised which are the best calculated to exterminate the insects and weeds attendant upon the previous crops.* By these means A CONSTANT SUCCESSION OF LARGE PRODUCTS MAY BE OBTAINED.*

* Sir John Sinclair.

"Swelling downs, where sweet air stirs
Blue hair-bells lightly, and where prickly furze buds
Lavish gold."—KEATS.

260. *Why should the nature of the soil determine the state and manner in which manure should be applied?*

Because soils being of very opposite natures *act upon*, and are *acted upon* by manures in *very varying degrees.* Organic matter decays very slowly in *stiff clay soils*, because of the *imperfect admission of the air.* Straw ploughed in acts very beneficially in such soils by *increasing their porosity*, the air admitted causing decay both of the straw and organic matter previously existing in them. Accordingly it will be found that the cases where dry straw had been beneficially employed were on *stiff soils*, and the immediate effect was not required or looked for.

261. On porous soils, the use of dry straw is calculated to *increase an existing evil*, because such soils have less organic matter in them, and are therefore more dependent on large supplies of rapidly acting manure.

262. *If immediate and powerful action is required*, fermented clay is to be preferred. In this case, in virtue of the moisture and azotized matters contained in the urine and excrements of cattle, fermentation is set up, and carried on so far that distribution in the soil does not check it, and thus nutritious matter is supplied abundantly upon growing crops. If, on the other hand, a smaller and longer-continued supply of nourishment is required, the straw may in some cases be ploughed in, and will, during its gradual decay, minister to growing crops.*

263. *Why do the same manures produce different results upon apparently similar soils?*

Because soils, in certain instances, *act chemically upon the manures*, and differ materially in their absorbing power. Experiments of a very interesting nature have been made by Mr. Thompson, Mr. Spence, Mr. Huxtable, Mr. Way,

* J. Shier, A.M., Fordyce Lecturer on Agriculture, University of Aberdeen.

"What different shapes in leaves are seen,
That o'er my head embower,
Clad in as many shades of green
As colours in the flower."—CLARE.

Dr. Voelcker, and others, for the purpose of ascertaining the *changes which liquid manures undergo*, when filtered through *different soils*.

264. Mr. Huxtable made an experiment in the filtration of the liquid manure of his tanks through a bed of an ordinary loamy soil; and found that after its passage through the filter-bed, the urine was deprived of colour and smell—in fact, that it WENT IN MANURE, and CAME OUT WATER. This implied the power of the soil to *separate from solution those organic substances which give colour and smell to the liquid*.

265. The experiments that have been made for the purpose of ascertaining the power of soils to absorb manure, place beyond dispute the fact that soils are gifted with a remarkable power of *separating from solution and retaining the salts of manures* UNTIL REQUIRED BY VEGETATION. But the precise circumstances and conditions in which that power is exerted, have not yet been ascertained.

266. It has been shown, however, that ordinary soils possess the power of *separating* and *retaining the bases of the different alkaline salts*, and certain animal and vegetable substances, and that this power extends to *all those substances to which we attach the chief value as manure*.

267. The newly-discovered property of soils explains and confirms the *variations in manuring operations*, which are made to *suit the nature of the soil*. Clay has been shown to be the active substance in retaining manure, and sandy and gravelly soils, not possessing a sufficiency of clay, will be expected to be less retentive of manure. Such is the fact, and soils of this description are said not to "*hold manure*." On such soils, manure must be applied more frequently, and in smaller quantities, than in stiffer soils, where, owing to the retentive power of the clay, the manure for several crops may be safely deposited.

268. If these inferences be correct, the only way of permanently improving a sandy soil is to CLAY IT; and it is notorious that the

"Your voiceless lips, oh flowers, are loving preachers,
Each cup a pulpit, ev'ry leaf a book,
Supplying to my fancy numerous teachers,
From loneliest nook."—H. SMITH.

light sands of some parts of Norfolk are made to bear crops only by copious dressings of clay. *Marl will not do, as it has none of the chemical properties of combining with manure, which clay possesses.*

269. The property of the soil to arrest putrefaction, and to combine with organic effluvia, is matter of common observation; *the practice of leaving a knife in the ground to remove the smell of onions,* which nothing else will do so well, is one instance of this property.

270. *The dog buries the bone* which he cannot consume at one time, in the soil, and returns for it at leisure. The *fox*, in his wholesale depredations, is known to *secrete his booty in the earth,* laying up stores in various places for his future use. In the same way, *venison is placed in the ground to keep it sweet whilst it mellows.* Every one has remarked that a country churchyard, where the bodies are not over-crowded, and the soil is sufficient for the absorption of the products of decay, *betrays to the senses no indication of the changes going on beneath the surface.* The North American Indians, having taken a "skunk," a species of polecat which stinks intolerably, in order to sweeten and render it fit for food, *bury the skinned carcass in the soil, where it speedily loses its offensiveness.*

271. But it may be asked, in such a case, *why does decay proceed at all, if the soil has a tendency to arrest it?* The answer is simply this—a LARGE MASS of animal matter, such as the *body of a dog,* buried in the earth, is only *very imperfectly brought into contact with the soil, and, consequently, decomposition takes place, with an absorption of the products by the surrounding earth.* The true influence of the soil must be looked for in the case of LIQUID ANIMAL PRODUCTS, *where perfect contact of the two is attained.**

272. The practical inferences that I drew from my inquiries on the absorbent power of soils, were these :—

273.—1. That *clay soils* might be manured *a considerable time before sowing,* WITHOUT LOSS.

274.—2. That *light shallow soils* should *not be manured* LONG *before sowing;* should not be HEAVILY MANURED *at one time;* and the manure should be kept AS NEAR THE SURFACE as practicable, *without leaving it uncovered.*

* Dr. Voelcker.

"Dear is the forest frowning over-head,
And dear the velvet greensward to the tread."—WORDSWORTH.

275.—3. That it is desirable to DEEPEN *the uncultivated soil of all* LIGHT LAND, as it thus acquires a greater power of HOLDING MANURE.*

276. We have, as the result of these investigations, an interesting illustration of the fact THAT THE SOIL IS THE GREAT WORKSHOP IN WHICH FOOD IS PREPARED FOR PLANTS, and that we can hope to attain unto a more perfect knowledge of the nutrition of plants, and the best means of administering to their special wants, *only* when we shall have studied in all their details *the remarkable changes which take place in soils when manuring substances are brought into contact with them.*†

277. The following are the PRACTICAL CONCLUSIONS which may be gathered from my experiments upon soils and manures :—

278.—1. *Liquid manure,* in contact with soil, *undergoes a number of chemical changes.*

279.—2. These changes are *greater in the case of clay and calcareous soils* than in the case of *sandy soils.*

280.—3. Passed through clay, loamy, and calcareous soils, liquid manure *leaves a considerable quantity of ammonia* in the soil.

281.—4. Under the same circumstances, liquid manure *parts likewise with potash and phosphoric acid.*

282.—5. *Sandy soils* remove from *liquid manure* but *little ammonia* and *not much potash.*

283.—6. With the *exception* of purely sandy soils, liquid manure, as used in practice, *leaves the greater portion of all the most valuable fertilizing matters in the generality of soils.*

284.—7. The *comparative power* of different soils *to remove ammonia, potash,* and *phosphoric acid from liquid manure* DIFFERS GREATLY.

* H. S. Thompson. † Dr. Voelcker.

> "What rapture swells with every sound
> Of morning's maiden hours,
> What healthful feelings breathe around,
> What freshness opes the flowers."—CLARE.

285.—8. Liquid manure *passed through sandy soils rich in soluble silica* TAKES UP *soluble silica.*

286.—9. Soils that absorbed *much ammonia* ALSO absorbed *much potash,* and the soils which absorbed *little ammonia* ALSO absorbed *little potash.*

287.—10. *Soda-salts* (common salt) are either *not at all removed* from liquid manure or only to a SMALL *extent.*

288.—11. *Chlorine,* and generally *sulphuric acid,* remain UNALTERED IN QUANTITY *in liquid manure passed through different soils.*

289.—12. In *most cases,* liquid manure left in contact with different soils *becomes richer in lime.*

290.—13. The *proportion of lime* which liquid manure takes up from the soils with which it is brought in contact *does not altogether correspond with the relative proportions of lime in different soils.*

291.—14. Liquid manure, passed through a sandy soil greatly deficient in lime, *became poorer in lime:* showing that THE PROPERTY OF SOILS OF STORING UP FOOD FOR PLANTS IS NOT CONFINED TO AMMONIA, POTASH, OR PHOSPHORIC ACID; *but that it is a property which manifests itself in a variety of ways.* Thus, soils rich in lime yield this substance to liquid manure; soils in which lime is deficient may abstract it from liquid manure. Again, potash *usually is removed* from liquid manure left in contact with soil; but, in particular cases, liquid manure *may even become richer in potash* after filtration through soil.

292.—15. Very soluble saline fertilizing compounds are *probably injurious* to vegetation when supplied *too abundantly* to the land.

293.—16. *All moderately fertile soils* have the power of *rendering the more important soluble fertilizing matters much less soluble;* but in none of the experiments were ammonia, potash, phosphoric acid, and other compounds that enter into the composition of the ashes of our cultivated crops, rendered *perfectly* insoluble.

294.—17. It does not appear probable that plants take up mineral food from the soil *in the shape of totally insoluble combinations.**

* Dr. Voelcker.

"The groves were God's first temples. Ere man learned,
To hew the shaft, and lay the architrave,
And spread the roof above them."—BRYANT.

295. *Why should the farmer regard mineral manures as among the "food" of plants?*

Because, whatever may be the refined speculations of chemists and physiologists, as to the *manner* in which minerals act upon vegetable organizations, it is obvious that, so far as the *farmer* is concerned, *that which increases the growth, without deteriorating the quality of any crop, must economically be considered as a proper* FOOD *of that crop.*

296. There is an erroneous impression, entertained by some practical men, in regard to *the way* in which mineral substances act when applied to the soil. By the term *manure* they generally designate such substances as they believe to be capable of *feeding* the plant, and hence reject *mineral substances*, such as *gypsum*, *nitrate of soda*, and generally lime, from the list of manures, properly so called. And as the influence of these substances on vegetation is undisputed, they are not unfrequently considered as *stimulants* ONLY.

297. The use of a *wrong term* is often connected with the prevalence of a wrong *opinion*, and may lead to grave errors in practice. I may, therefore, be permitted to say that it is almost *demonstrated* that plants DO *feed upon dead unorganized mineral matter*; and that you *really manure the soil*, as well as *permanently improve* it, by adding to it such substances of this kind as are *found by experience to promote the growth of the crops.**

298. *Why does lime act beneficially upon a variety of* [illegible] *?*

Soils and subsoils, far below the reach of ordinary farm operations, *always* contain a very sensible quantity of AMMONIA.

299. *The action of lime, in the presence of water, is to set free from the soil as nearly as possible one-half of the ammonia.* It is probable that in the soils improved by

* Professor Johnston.

"High climb the pulse in many an even row,
Deep strike the ponderous roots in soil below,
And herbs of potent smell and pungent taste."—CRABBE.

lime, the ammonia of the soil is *too tightly locked up.* Thus, lime may be the remedy at the command of the farmer, rendering *immediately available* stores of wealth, which can otherwise *only slowly be brought into use.*

300. In this view, lime would well deserve the somewhat vague character that has been given to it, namely, that of a STIMULANT, for its application would be in some sort an application of ammonia, whilst its *excessive* application, by driving off ammonia, would lead to disastrous effects. If there be any truth in these deductions, it points out the importance of employing lime in *small quantities* at *short intervals*, rather than *in large doses* once *in many*

301. The chemical action of *lime*, and the *effect which it produces as a manure*, appear to be of two kinds. On one hand, it acts upon *vegetable mould* by accelerating its decomposition, and rendering it *soluble*, and then fits it to enter the roots of plants. This is the reason that a mixture composed of *lime* is the more efficacious, the richer the soil is in *mould*, and that its action is the more sensible, in proportion as the vegetable matter is of an insoluble nature. *Lime* deprives *some mould* of its acidity, and renders it fertilizing. But, on the other hand, there is every probability that by means of its *carbonic acid*, lime also produces *some other* effect, and *furnishes the plants with some nutritive matter.* The roots of certain vegetables *appear to have the faculty of depriving lime of its carbonic acid*, which it immediately *re-absorbs in equal proportion from the atmosphere.* Every one must be aware that *lime* communicates a peculiar degree of *vigour* to some plants, and that the roots of these can even *penetrate through rough limestone*, and in a manner *decompose* it. This remark is particularly applicable to *sainfoin*, the tap-root of which *penetrates from ten to twenty feet deep into calcareous stones, and there puts forth clusters of lateral roots which render the stones loose and friable all round them.*†

* J. T. Way.

† Thäer's "Principles of Agriculture."

"O how canst thou renounce the boundless store
Of charms which Nature to her votary yields,
The warbling woodland, the resounding shore,
The pomp of groves, and garniture of fields."—BEATTIE.

302. *Why is lime more beneficial as a manure than chalk?*

Because chalk acts merely *by forming an earthy ingredient of the soil*, and its efficacy is proportionate to the deficiency of calcareous matter, which, in larger or smaller quantities, seems to be an essential ingredient of all fertile soils; necessary, perhaps, to their proper texture, and as an ingredient in the organs of plants.

303. Burnt lime, possessing *active* properties, *operates as a decomposing agent upon animal and vegetable matter*, and seems to bring it into a state on which it becomes more rapidly a vegetable nourishment; gradually, however, the lime is *neutralized* by carbonic acid, and converted into a substance resembling chalk; but in this case it more perfectly mixes with the other ingredients of the soil, is more generally diffused and freely divided; and it is probably more useful to land than any calcareous substance in its natural state.*

304. It follows, therefore, that when lime is conveyed from the kiln to the field, *the sooner it is dispersed the better;* otherwise it will be restored to the state of chalk, and lose some of its fertilizing properties.

305. *What change does chalk undergo by burning?*

Chalk is a carbonate of lime, or lime united with carbonic acid, and also water. When burnt, the heat *drives off the carbonic acid*, in the form of carbonic acid *gas*, volumes of which may be observed ascending from the kilns, and the water is *dispersed in the form of vapour.*

* Sir H. Davy.

"O'er every field and golden prospect found,
That glads the Ploughman's Sunday morning's round,
When on some eminence he takes his stand,
To judge the smiling produce of the land."—Bloomfield.

306. The farmer must not fall into the very common error of supposing that anything is *added* to lime by the action of fire; on the contrary, it *loses* very materially in weight, by being deprived of its carbonic acid gas—a loss, however, which it soon recovers by exposure to the atmosphere, having a strong tendency to aborbs that gas.

307. A knowledge of these facts is of considerable value to the farmer, *even on the score of carriage*, independently of the greater value of lime as a manure; for, in some cases, the object of the needless weight of water and carbonic acid in chalk is very material, as will be seen by the following analysis of the chalk of Kent:—

	Parts.
Water	24·0
Carbonic acid	34·2
Lime	41·8
	100

With some minute proportions of oxide of iron and silica.

308. So that, *when the farmer carts* FORTY-ONE *tons of fresh lime, he conveys as much real manure to his soil as if he carried* ONE HUNDRED *tons of chalk.** Even should the water and carbonic acid be ESSENTIAL to the manure, *the lime will absorb its original proportions of these from the atmosphere, within a few days after being laid down.*

309. *Why have prejudices existed in some cases against the use of lime?*

Because of the *different qualities* of limestones. There is a very considerable quantity of lime made from the *magnesian* limestones, called by farmers "hot lime." This differs from common limestones, by containing magnesian earth, and in some cases it has proved highly injurious to vegetation, when applied in large quantities in its caustic state.

310. When lime is known to be of this nature, it should only be applied in *limited quantities*, for the calcined magnesia of the

* Johnson's "Farmer's Encyclopædia."

> "And for our coffers, with too great a court,
> And liberal largess, are grown somewhat light,
> We are enforced to farm our royal realm,
> The revenue whereof shall furnish us."—SHAKESPEARE.

limestone remains for a *considerable period* in its pure caustic form, without absorbing carbonic acid gas from the atmosphere, and in this state its effect is very pernicious to many kinds of plants. It is only when pure, however, that magnesia is prejudicial to vegetation; by exposure to the atmosphere, it gradually and slowly absorbs carbonic acid gas, becomes carbonate of magnesia, and in this state forms a part of many cultivated plants.*

311. The practical deduction is, *that the proportion applied to the soil should be smaller than in the case of the common limestone, and that a longer period of exposure should be allowed before spreading.*

312. There are four circumstances of *great practical importance,* which cannot be too carefully considered in reference to the theory of the operation of lime. These are—

313.—1. That lime, unless in the form of *compost,* has *comparatively little or no effect* upon soils in which organic matter is deficient.

314.—2. That its apparent effect, at least upon the corn crop, is *inconsiderable during the first year* after its application, *compared with that which it produces in the second and third years.*

315.—3. That its effect is most sensible *when it is kept near the surface* of the soil, and gradually becomes less as it sinks towards the subsoil. And,

316.—4. That under the influence of lime, *the organic matter of the soil disappears more rapidly than it otherwise would do;* hence after it has thus disappeared, fresh additions of lime are much less beneficial than before.

317. It is obvious from these facts, that *in general,* the main beneficial purpose served by lime is to be sought for in the nature of *its chemical action upon the organic matter of the soil*—an action which takes place slowly, which is hastened by the access of air, and which causes the organic matter itself ultimately to disappear.†

318. *Why should not lime be added to night-soils for manures, with the view of disinfecting them?*

Because while thus *removing the objectionable odour* of the

* Thäer. † Professor Johnston "On the Use of Lime."

> "To solemnize this day, the glorious sun
> Stayes in his course and plays the alchymist,
> Turning with splendour of his precious eye,
> The meager cloddy earth to glittering gold."—SHAKESPEARE.

soil, *we deprive it of a great amount of nitrogen*; for the action of lime, after decomposing those component parts whichcontain nitrogen, to form ammonia, also tends to *drive away the ammonia altogether*. Some nitric acid will, indeed, be produced from the nitrogen of the night-soil by the excess of the oxygen of the atmosphere, and in that case nitrates of lime and ammonia will be formed, but the greater proportion of the nitrogen will combine with hydrogen, and escape in the state of gas.

319. The best plan is, to cover and mix night-soil with earth abounding in *humus*, with which a little *marl* may be mixed, and so leave it to ferment. All the ammonia is thus *united with the humic acid* as soon as formed. This process frees it from the odour which is so great an obstacle to its employment; and when the heap nas been several times stirred, it may be easily spread.*

320. *Why are sea sands beneficial as manures?*

Because they contain from forty to seventy per cent. of calcareous substances, *or carbonate of lime;* the *sea salt* with which it is impregnated also contributes largely to its fertilizing properties. Farmers prefer the sand *which the tide has just left*, and which consequently contains *much saline matter*, together with fragments of sea-weed, and occasionally animal matter derived from dead marine creatures, among which are the tenants of small shells, but little decomposed in them.†

321. *What are coprolites?*

They are *fossils*, which usually occur of a conical shape, are generally found in the ancient calcareous formations, and are shown by Dr. Buckland, in his "Bridgewater Treatise," to be the petrified excrements of extinct animals. They

* Dr. Sprengel. † Sir H. T. de la Bèche.

"'Tis beauty all, and grateful song around,
Join'd to the low of kine, and numerous bleat,
Of flocks, thick-nibbling through the clover'd vale."—THOMSON.

also are represented to be found in the State of Maine, and occur in numerous limestone formations in other parts of the United States. They are most frequently found in layers of rock, and are generally associated with other fossils of various compositions, forms and textures. Sometimes, however, they occur as water-worn pebbles, coarse gravel, or in a more comminuted state in the soil. An analysis of a sample made by Mr. Herapath gives of

Phosphate of lime, magnesia, and iron	53·7
Carbonate of lime	28·4
Sulphate of lime	0·7
Silica	13·2
Water	3·4
	99·4

322. *Why do coprolites supply good manure?*

Because, besides the other ingredients, the above analysis indicates that coprolites contain an equivalent of 26¾ per cent. of *phosphoric acid*, which is an invaluable fertilizer. They are about as rich in phosphate and carbonate of lime, as *the recent bones of an ox*, when perfectly dried, and deprived of their fat. The latter yield of *phosphate of lime* 56¾ per cent., and of phosphate of magnesia 3¼ per cent., which is equivalent to 26$\frac{7}{16}$ per cent. of phosphoric acid. It is to be observed, however, that coprolites, in general, are intensely hard, so much so, that it requires powerful machinery to grind them; and that, even when reduced to powder, they are not sufficiently soluble of themselves for direct application to the soil. They are readily dissolved by sulphuric acid, and then afford a most excellent manure for turnips, cabbages, rape, &c.*

* D. J. Browne.

"Then rise the tender germs upstarting quick,
And spreading wide their spongy lobes, at first,
Pale, wan, and lurid; but assuming soon,
Strained through the friendly mats, a vivid green."—COWPER.

323. Professor Henslow, whose great acquirements as a botanist had not prevented his attending to other branches of science, had noticed in 1842 some nodules at Felix Stowe, on the coast of Suffolk. In 1843, haunted with the idea that they were something of importance, he returned to Felix Stowe, collected a quantity of them, and placed them in the hands of Mr. Potter for analysis. The analysis showed them to be fossils, commonly called coprolites; and that they consisted of animal excrement, containing from 50 to 55 per cent. of *phosphate of lime.* From this discovery Professor Henslow might have realized a considerable fortune. The quarry of coprolites was to be had at a common rent, and there were manure manufacturers prepared to pay for the information, but he "did not consider such a course consistent with his position as a man of science and a clergyman," and after keeping silence on the subject for some months at the request of Mr. Potter, "who wished to have the chance of availing himself of the discovery," he gave the results of his investigation to Mr. J. B. Lawes, who made the superphosphate obtained from coprolites the subject of a patent, which he was not able to maintain. Subsequently, beds of coprolites were discovered in Cambridgeshire, Hampshire, and Dorsetshire, and further investigations in Norway placed Mr. Lawes in the exclusive possession of great beds of a mineral, called *apatite,* rich in phosphates, of which he imports whole cargoes for his manufactory at Bow, near London. However, the superphosphate of lime, produced from fossils being *much less soluble than that from fresh bones, can only be usefully applied when mixed in moderate proportions with the latter.**

324. *Why does salt act as a fertilizer?*

Because:—1. *It is a direct constituent of plants.* When salt exists in a soil it is found in various proportions in the crops cultivated by the farmer. It always abounds in plants growing near the sea shore, and when applied on inland soils is taken up readily by any plant. Thus, Sir G. Sinclair found in 50 parts of the ashes of wheat chaff 2¾ of common salt, and from 40 parts of the ashes of chaff from the same crop dressed with salt, he obtained 4 parts of common salt.

* Quarterly Review, 1858.

"The penetrative Sun,
His force deep darting to the dark retreat
Of vegetation, sets the steaming power
At large, to wander o'er the vernant earth."—THOMSON.

available, and *active*; and in one of these only, the ACTIVE, are they of service to the husbandman.

336. When a chemist has to analyse a mineral that is of difficult solubility by an ordinary agent, it is a common practice to submit such a mineral or other substance to the agency of *heat*, which sometimes wholly, but generally partially, has the desired effect.

337. *The benefit of burning land for manure* will be found most beneficial on such soils as contain the largest amount of the necessary mineral constituents of plants in what has been previously alluded to as existing *in a passive state*, and on which the agency of heat will *reduce the same to an active or available form*. At the head of these soils will be found *stiff clays* and *marls*; next *stiff loams*, and *loams* throughout their great variety of *gravelly*, *sandy*, &c., down to *silicious* or *sandy soils*, on which burning is *utterly ruinous*, except for CLEANING operations.*

338. *Why does rape-dust afford a very fertilizing manure?*

Rape-dust, the seed of the rape plant, after the oil has been extracted from it, owes its fertilizing qualities to the large amount of *nitrogen* which it contains. *Eight* tons of rape-dust afford as much nitrogen as *one hundred* tons of farm-yard manure. It is also *greatly superior* to farm-yard manure in soluble organic matter, *equal* to it in phosphates, and *inferior* to it slightly in saline matters; or, taking all together, one ton of rape-cake equals twenty tons of common dung.†

339. *Why is rape-dust chiefly valuable to grain crops?*

First, because all green crops require a large supply of inorganic matters, which rape-dust is deficient in, and

* T. Rowlandson, Journal of the Royal Agricultural Society.

† J. Hannam, North Deighton, Wetherby. Prize Essay of the Wetherby Agricultural Society.

> "Beyond bleak Winter's range, beyond the Spring,
> That rolling earth's unvarying course will bring,
> Who tills the ground, looks on with mental eye,
> And sees next Summer's sheaves and cloudless sky."—BLOOMFIELD.

derive, by their large system of leaves, a greater supply of food from the air than the grain crops. *Secondly*, because all plants require a supply of *nitrogen* to *perfect their seed*, which nitrogen rape-dust possesses in an extremely large proportion.*

340. *Why is rape-dust not lasting in its effects?*

Because it contains such a *large proportion of soluble organic matter*, and so little of the earthy inorganic substances, or ashes, that fermentation and putrefaction take place immediately; whence its carbonic acid and ammonia are supplied to the roots of the plant in large proportions at the *commencement of its growth.**

341. *Why does rape-dust produce a marked effect upon thin poor soils?*

Because of the *deficiency of those soils* in the *vegetable* and *animal matter* necessary to supply the crop with *carbonic acid* and *ammonia.* Because, also, these soils often possess a large share of the mineral constituents of plants, *in which matters rape-dust is deficient.* So that the *capabilities of the manure* are adapted to the *wants of the soil.**

342. *Why is rape-dust most certain in its effects when applied to winter-sown wheat?*

Because, during *showery seasons*, much of the *ammonia* and *carbonic acid of rape-dust*, which in dry weather rise into the atmosphere and *fly off as gases*, are *washed to the root of the plant;* which, owing to the liberal supply of moisture, is in a healthy and active condition; and can, consequently, *assimilate a larger supply of food.*

* J. Hannam.

> "The Sower o'er his heavy hopper leans,
> Strewing with swinging arms the pattering beans,
> Which, soon as April's milder weather gleams,
> Will shoot up green between the furrowed seams."—CLARE.

343. In drought, *the reverse is the case;* being poorly supplied with water, the plant languishes, and can appropriate but a slight portion of the nutritive gases, which, when not in solution or combination, quickly escape.*

344. *Why does rape-dust succeed best upon strong land?*

Because *the soil is not so permeable to the atmosphere* as that of a sandy or calcareous nature; hence a much less portion of the *carbonic acid and ammoniacal gases of the tillage escape* during the winter, and at the same time the active putrefactive fermentation of the rape-dust causes a disintegration or pulverization of the soil round the roots of the plant; an operation of greater value to stiff soils, than to free ones.*

345. *Why should not a large quantity of rape-dust be applied at one time?*

Because the *too active decomposition may,* in such a case, *destroy the germ of the seed,* or cause the produce to yield a coarse and light weighing sample. The effect of young plants being *too largely supplied* with rich organic manure may be thus explained. The plant is stimulated to an increased action at one time, which the other matters in the soil cannot maintain, and the consequence is that the seed is deficient in some of its constituent elements, and the straw soft and unproductive.*

346. *Why is it necessary to apply saline and earthy manures after a course of rape-dust?*

Because we cannot *maintain fertility without returning to the soil all that we have taken from it.* And, in the course of

* J. Hannam.

"The trudging sow leads forth her numerous young,
Playful, and white, and clean, the briars among,
Till briars and thorns increasing fence them round,
Where last year's mould'ring leaves bestrew the ground."—BLOOMFIELD.

crops, we take away many earthy and saline substances, while we return little of the former, and scarcely any of the latter, when we apply rape-dust.*

347. *Why is the drill system of applying rape-dust the best?*

Because, by applying it upon the broad-cast system, *as a top-dressing*, a great portion of its *nutritive gases is wasted* in the atmosphere, owing to the quick decomposition which takes place. By spreading it over the broad surface, before the seed is drilled, a loss arises from the same cause; for as the tillage is not in proximity to the seed, a portion of ammonia and carbonic acid given off during its quick fermentation, is absorbed by the weeds, or escapes into the air, before the young plant can send its fibres in search of it.*

348. Let it not, however, be forgotten that "to every rule there is an exception;" hence, though we contend for the drill method *as a system* there are cases in which its use would be injudicious. Thus, upon stiff soils, in wet weather, it would not do to use the drill, as the treading of the horses has in such cases an extremely evil effect. The adhesive nature of the soil, also, prevents the machine from working properly. Upon clover stubble, or light soils, *pressing* is attended with advantage, as it gives to the root of the plant a firm sole, and affords it a better mechanical support against the storms of winter.*

349. *Why have plants that grow in poor soils large fibrous roots, and stunted stems?*

Because, *if the fibres of a root find little or no food near*, they increase in number and length, and *spread over a larger surface, in search of sustenance*. In this way the plant *exhausts its vigour;* the numerous roots being formed at the expense of the matters which should have assisted the growth of the stem.*

* J. Hannam.

"Nature! great parent! whose unceasing hand,
Rolls round the seasons of the changeful year,
How mighty, how majestic, are thy works!
With what a pleasing dread they swell the soul!"—THOMSON.

350. *Why is it judicious to place the manure as near to the seed as possible?*

Because the plant has then *no necessity to exhaust itself* unduly by the fibrous extension of its roots; and as decomposition will be going on at the time when the plant is rearing its stem and putting out the green leaf, it will be well supplied with liquid and gaseous food *at the most critical period*, and consequently will be able to develope a stouter stem and leaf, and in less time than if the manure was further distant and more diffused.*

351. *Why is there danger in drilling rape-dust with the seed?*

Because, if *too much* rape-dust be applied, it will *over-stimulate* the young plant. Care must be taken, therefore, in the application of this manure, because, if drilled in with the seed, it would inevitably burn it up: when used for barley, the dust is sown about eight days before the seed.†

352. This is true in a limited sense. Rape-dust will kill the seed *if a large quantity be used.* By the drill system, however, we so economize the virtue of the dust, that there is *no occasion to use a large quantity.**

353. *Why, as a general rule, should manure be placed in as close proximity as possible to the plants it is designed to nourish?*

Because, in all cases of decomposition, the disengaged substance enters into new combinations *at the very instant of its disengagement*, much more readily than it does at any subsequent period.

* J. Hannam. † Dr. Madden.

"As stubborn steers by brawny ploughmen broke,
And joined reluctant to the galling yoke,
Alike disdain with servile necks to bear
Th' unwonted weight, or drag the crooked share."—POPE.

354. Thus, during the putrefactive fermentation of vegetable substances, *a quantity of nitrogen is disengaged*, and if this takes place under certain favourable circumstances —such as the presence of calcareous matters, potash, and a dry warm temperature at the moment it is formed—the nitrogen combines with the oxygen, forms nitric acid, which unites with potash,—thus nitrate of potash, saltpetre, is formed; but if the nitrogen is *once fairly disengaged, almost every endeavour of the chemist has failed in making it unite with oxygen, so as to form the acid of saltpetre.**

355. The question of *the best method of applying manures*, is one upon which differences of opinion exist, as will be seen from the following practical and theoretical considerations:—In the old or broad-cast system of manuring, it is evident that the *whole soil*, to a given depth, was made to participate in the benefits of the application, and the whole soil, therefore, was in the position of what Tull called a "pasture," or feeding ground for plants. The natural tendency of the roots of plants is undoubtedly to spread themselves and to run out in every direction in search of food.

356. *The practice of drilling manures in close proximity to the seed* is founded upon the supposition that, by supplying the plants with food immediately within reach, you thereby diminish the amount of energy which they are otherwise called upon to expend in seeking for it, and enable them in a given time to obtain the means of building up a greater amount of vegetable structure. But the acceptation of this theory involves two assumptions—the first, that plants with a supply of food within their reach do really content themselves with that supply, and cease to throw their roots to a greater distance; the second, that the manures are such as require no preparation by combination with the materials of the soil, but are at once, and in the form in which they are applied, taken up by the plant and appropriated to its nourishment.

357. The former of these assumptions is in a manner dependent on the latter, for, if plants can really take up and make use of the different substances furnished to them in manure *in the state in which we apply*

* Cuthbert Johnson.

"It became necessary to pursue some regular method of providing a constant subsistence; and this necessity produced, or at least promoted and encouraged, the art of agriculture."—BLACKSTONE.

them, there seems no good reason why they should wish for more. But I confess that the unexpected aspect which has been given to the question of the food of plants by experiments made by Mr. Thompson and myself would lead to *a far different conclusion.* The impression left on my mind by these experiments, unsatisfactory and incomplete as they still are, is *that the office of the soil is not merely as a place for the roots of plants to take root in and obtain a mechanical attachment to, but as an agent for the alteration and preparation of these manures*—itself taking part in the necessary changes—*is of the very last importance to healthy vegetation.*

358. Of this circumstance there is no doubt—that healthy vegetation of land plants *will not proceed in water,* whatever may be the care and attention given to supplying the plants with food, whilst the same food, distributed through a given quantity of soil, becomes at once available to the sustenance of plants. It is also certain, from experiments, that the ingredients of manure, both *mineral* and *organic,* DO enter into *a new state of combination with the soil,* and that, consequently, in the ordinary course of nature, plants DO directly *take these means of support and growth from the compounds so formed.* It needs, therefore, only a very small amount of logical reasoning to convince us that, as this is the usual and natural, *so it must be the healthiest and best form in which the substances which constitute the food of plants can be offered to their acceptance.*

359. *Sulphate* and *muriate of ammonia,* added to water in which the roots of plants are placed, not only *fail to nourish,* but *actually destroy them.* On the other hand, these salts distributed through a small portion of soil, produce the most luxuriant vegetation. If again we find that *sulphate of ammonia,* and the *muriate* of the same base, immediately after mixture with the soil cease to remain as such, but *enter into union with certain ingredients of the soil,* are we not justified in believing that *it is this new combination, or something derived from it, which is effectively the food of the plant, and that the soil is an all-powerful agent in the preparation of that food?*

360. I am unwilling to form a conclusion of this importance without due and careful consideration; but it does appear, to say the least, questionable, whether plants can *healthily* subsist on the crude and

"But happiest they, who drooping realms relieve!
Whose virtues in our cultured vales appear!
For whose sad fate a thousand shepherds grieve,
And fading fields allow the grief sincere."—SHENSTONE.

various substances supplied in manure *until these substances have undergone the modifications which mixture with the soil will produce.*

361. The bearing of this subject on the drilling of manures is evident; this mode of application almost *pre-supposes the power of the plant to feed upon the unaltered ingredients of manure;* and although, undoubtedly, these substances *do come into contact with a certain quantity of the soil,* it seems to me well worth consideration whether, by carrying out the plan of drilling manures in its *fullest sense,* we may not be *overlooking the fact that we thereby limit the roots of the plant to an area of "pasturage" infinitely smaller than they might advantageously enjoy,* and whether *a moderate use of this method, and a partial return to the system which should make the whole soil participate in the benefit of manure, is not more consonant both with practical information and scientific truth.**

362. *Why is rape-dust less efficacious for turnips than for corn crops?*

Because the turnip requires a large portion of *inorganic* matter, such as phosphate of lime, to perfect its growth; which phosphates we are in the habit of supplying by the use of bones, while *rape-dust contains but a small proportion of these matters.*

363. Let us, however, not draw *too general* a conclusion from this fact. It should be remembered that the turnip is a plant subject to many enemies during its infancy, and that it has a large system of leaves, by which it extracts nourishment from the air (hence the bulb is generally found to be in proportion to the size of the broad leaf); therefore, it should be one object to give it such manure as will act readily, and cause it quickly to develope those leaves by which it may draw its carbon from the atmosphere, and become, in one sense of the word, *independent of the soil, and out of danger from insects.*†

* J. T. Way, Consulting Chemist to the Royal Agricultural Society.
† J. Hannam.

"The lamb thy riot dooms to bleed to-day,
Had he thy reason, would he skip and play?
Pleased to the last, he crops the flowery food,
And licks the hand just raised to shed his blood."—POPE.

364. *Why should turnip seed never be placed in contact with manure of active fermentive qualities?*

Because the seed of the turnip is so small, and the *budding germ so tender*, that the seed itself, its vital principle being destroyed by too powerful a chemical action, becomes decomposed—a result peculiarly liable to occur where *rape-dust* or *guano* is employed.

365. *The following* PRACTICAL CONCLUSIONS *may be deduced with regard to the use of rape-dust:—*

366.—1st. That rape-dust, being beneficial to the growth of grain in general, is most marked in its effects upon *thin, poor soils.*

367.—2d. That it *does not operate so well* in a *dry* season, as in a *moist* one.

368.—3d. That it is most certain in its effects upon the *winter-sown wheat-crops;* but, in *favourable seasons,* most remunerative on the *spring crops.*

369.—4th. That it answers *best on strong soils for the wheat crop.*

370.—5th. That it is not judicious to apply *large quantities at one time.*

371.—6th. That it is necessary, after using rape-dust for several rotations, to *apply dressing of saline and earthy matters.*

372.—7th. That rape-dust should *not* be drilled with turnip seed. And that it is *less advantageous to turnip crops* than to *grain.**

373. *Why, in favourable seasons, is the return upon rape-dust most remunerative upon spring crops?*

Because when the germinating seed is *supplied with moisture,* there is no cessation of vegetation after the plant appears, the nutritive gases being assimilated as fast as they are given off. And as there is no waste of these, as in wheat during winter, when the plant cannot appropriate

* J. Hannam.

the nourishment, *less* tillage has an *equal* effect—*equal* tillage a *greater.**

374. *Why does the treatment of bones with sulphuric acid improve their qualities as manure?*

Bones may be roughly stated to consist of *fat, jelly,* and an *earthy matter* called *phosphate of lime.* When they were first employed as manure, it was *doubtful,* of course, to *which of these substances* they owed their *beneficial effect;* and many persons were unwilling to purchase *bones which had been boiled,* and had lost their grease.

375. It was soon found, however, that *boiled bones were as good manure as those that were unboiled.* There still remained *two substances,* either of which might be their active principle. *Burnt bones* were also found to retain their fertilizing properties.

376. Now, as fire drives out of the bone *the jelly,* which holds it together, there remains *only the earthy matter* behind, thus proved to be the manuring substance. This being *phosphate of lime,* chemistry suggested that since the lime was in so small a quantity, the *phosphoric acid* united with it must be the true manure contained in the bones, and that *if the lime were taken from it by sulphuric acid,* the phosphoric acid *thus set free* would be greatly strengthened in its immediate activity. Experiments have wonderfully corroborated the predictions of chemical science.†

377. The following are plain *Directions for treating bones with sulphuric acid:*—Calcined bones are to be reduced by grinding to a very fine powder, and placed in an iron pan with an equal weight of water (a cast-iron trough, such as are sold for holding water for cattle, will do); a man with a spade must mix the bone with the water until

* J. Hannam. † Ph. Pusey, Esq.

"In this order the whole was tilled, and the harvest or product laid up in several granaries, out of which it was distributed by officers for that purpose."—SIR W. TEMPLE.

every portion is wet; while the man is stirring, an assistant empties at once into the pan sulphuric acid, 60 parts by weight to every 100 parts of bone; the acid is poured in at once, and not in a thin stream as commonly recommended; the stirring is continued for about three minutes, and the material is then thrown out. With four common farm-labourers and two pans, I have mixed two tons in one day. The larger the heap that is made, the more perfect the decomposition, as the heap remains intensely hot for a long time. It is necessary to spread the superphosphate out to the air for a few days, that it may become dry.*

378. *Four bushels of bones* may be considered *a fair allowance of an acre,* and these in a fine state of bone dust will weigh about 180lbs. This quantity contains about 12½lbs. of carbonate of lime, consisting of carbonic acid 5½ parts, and lime 7 parts, which will require 10lbs. of sulphuric acid to convert it into sulphate of lime or gypsum. This is the first result of the mixture, and is the cause of the very unpleasant fumes which are given off, and which consist in fact principally of carbonic acid disengaged from the carbonate of lime in consequence of the superior affinity which lime has for sulphuric acid. This result takes place before the acid acts on the phosphates of the bones, and thus it is *that when a small quantity of acid has been sprinkled over bone-dust, the good effect has been but moderate;* the carbonate of lime alone has been acted upon, and the phosphate of lime, the *essential part,* has remained *undecomposed.*

379. *The quantity of phosphate of lime* existing in the four bushels of bones is about 106lbs., containing 47lbs. of lime and 59lbs. of phosphoric acid. If we consider superphosphate of lime to contain a double portion of acid—a fact, however, not quite decided, then 33lbs. of sulphuric acid will be required, which, by uniting with half the lime, or 23½lbs., forms gypsum, and leaves the other moiety of lime united with a double portion of phosphoric acid in the state of a superphosphate. Thus 43lbs. of acid will be required to effect these changes, leaving any additional quantity for other purposes.†

380. *A very convenient and cheap vessel for manufacturing the mixture* is a sugar-hogshead, having its holes stopped with plaster of

* Mr. Lawes, of St. Albans. † W. C. Spooner.

> "But th' earth herself, of her owne motion,
> Out of her fruitfull bosome made to growe
> Most dantie trees, that, shooting up anon,
> Did seem to bow their blossoming heads full lowe."—SPENSER.

Paris. It is very desirable to avoid if possible any measuring or weighing of the acid, as it is *so very dangerous a substance to handle.* Many serious accidents occurred to my knowledge during the last year, and it is very difficult to impress farm servants with a sufficient degree of caution, or even to convince them that a liquid which appears so colourless will burn their skin and clothes. In emptying a carboy of acid, even into a tub, it is difficult to prevent a little slopping about and damaging the clothes of the attendants, as well as the basket, &c., which contains the carboy. To prevent these unpleasant consequences I have adopted the following plan:—The carboy is placed on a stage or cask the same height as the sugar-hogshead, into which is put the precise quantity of bone-dust we intend mixing with the carboy of acid. The water is now added with a watering-pot having a rose at the end, so as to disperse it thoroughly, and the carboy of acid is then emptied by means of a syphon. This syphon is formed of a piece of block-tin pipe, which can be bent into any form, about three-quarters of an inch in calibre and four feet in length. A brass cock is soldered to the long end of the syphon, on which the rose of a watering-pot may be placed. The syphon is now filled with water, and its long end closed with the cock, and the small end with the hand or finger. The latter is then quickly inserted into the mouth of the carboy, the cock turned on, and the acid will continue to flow till the vessel is nearly empty, without any assistance, so that the attendant has no occasion to expose himself to the injurious and offensive fumes which almost immediately begin to escape. He may, however, approach the windward side of the tub, and give the mixture a little stirring, which should be continued for some little time afterwards, so that the mixture may be complete. A convenient utensil for this purpose is a fork with two prongs, long in the prong, bent at some distance from the prongs nearly at right angles, and fixed in a wooden handle. On the same day a fresh lot of bones may be added, and the process repeated until the hogshead is nearly full. In two days afterwards the mixture may be shovelled into a heap, and either remain till wanted or mixed at once with a certain portion of ashes. It should be shovelled over several times and ashes added at each time of turning, which will thus render the mixture fine and dry enough to pass through an ordinary drill.*

* W. C. Spooner.

"Young kids light skipping, and the timorous fawns
Brush through the copse, and bound along the lawns;
While in fresh pastures, or on fallows gray,
Lambs nimble in the wantonness of play."—FAWKES.

381. *When persons are accidentally burnt by vitriol*, they should lay on the burn with a feather, the white of eggs mixed with powdered chalk; or the powder of white-wash, scraped from the wall, will do.

382. *A new method of preparing bone compost, without sulphuric acid*, is stated to have been successful. The experimenter, a high authority, says:—I procured three cart-loads of crushed bones, and, having wetted them, mixed one cart-load with two loads of peat ashes, another with two loads of coal ashes, and the third load with two loads of sterile white sand, dug from some depth, and quite unfit in itself to support vegetation. The three heaps were made up as compactly as possible side by side. In a few days they all heated equally, becoming too hot in the middle to be borne by the naked hand; in a few more the bones had disappeared in each heap equally, being reduced in general to a blue mouldy substance. Some corroded fragments, indeed, remained in the centres; and the outsides, to the depth of five or six inches, were unchanged, because there the heat was insufficient.

383. The experiment having so far succeeded, the next step, of course, was to try the effects of the dissolved bones on the land, and in May, 1846, they were used upon half-acre lots of early turnips in equal proportions; the crops produced by each mixture were equally good. But as a single experiment does not justify one in putting forth the recommendation of a new practice, I waited for the result of another year's trial.

384. The result of the whole seems to recommend decidedly the mode of preparing bones which I propose, and, but for the mistake of my men in mixing so small a proportion of sand, I believe the effect would have been stronger. Practically, I think that *the manuring virtue of bones is increased from three to four-fold by this simple process*, which cannot be said to cost anything. It is within the reach of every one to practise on a large scale and at a few days notice. Though I mixed barren sand with the bones for the sake of experiment, any light loam would no doubt answer as well or better—the soil itself, in fact, of any farm where bones themselves are likely to answer; and the labour is so trifling, that it is not worth speaking of.*

* Mr. Pusey; Journal of the Royal Agricultural Society.

"For them his plough turns up the destined lands,
Whence stormy winter draws its full demands;
For this the seed minutely small he sows,
Whence sound and sweet the hardy turnip grows."—BLOOMFIELD.

385. *Why, in making the bone compost, should the water be poured upon the bones first?*

Because the bones then become partially saturated, and the acid, from its great affinity for water, *rushes as it were into the pores of the bones to get at the water*, and thus the bones become more rapidly and perfectly mixed with and acted upon by the acid. When no water is employed, and the bones are not entirely in the state of fine dust, as they never are, unless purposely sifted, the surfaces of the small pieces of bones become acted on by the acid, and a coat forms around them which seals up the interstices of the bones, and prevents the acid from penetrating.*

386. *Why is sulphur an important element in agriculture?*

Because it enters largely into the composition of animal and vegetable substances. Of the hair on cattle, and wool on sheep, five per cent. consists of sulphur, which is derived from their food; and no albuminous compounds can exist without it.

387. Sulphur in the state of sulphuric acid has also a high value of an *indirect* kind. It unites with and retains the volatile and valuable ammonia, and yet, while fixing it, in no degree diminishes its solubility. It also unites with various other bases, and forms salts of great agricultural importance.†

388. *Why is sulphuric acid inferior to muriatic in the preparation of bone-compost for turnips?*

Because it is *stronger*, *cheaper*, has *greater specific gravity*, and contains *much less water*. On mixing it with water, it

* W. C. Spooner. † Rev. W. R. Bowditch.

"Vale vetches would you sow, or lentils lean,
The growth of Egypt, or the kidney bean?
Begin when the slow waggoner descends,
Nor cease your sowing till mid-winter ends."—DRYDEN.

much higher temperature is attained, which conduces to the dissolving process, particularly of the organic part of the bones.

389. In addition to these reasons,—in the trials that have been made, *muriatic acid* has been found *somewhat inferior.* The muriate of lime formed by muriatic acid and bones, has, however, a great attraction for moisture, and may prove advantageous in a *dry season.* And it is not improbable that an equal quantity of bones, prepared separately with the two acids, and afterwards mixed together, might be more productive than bones prepared with either acid alone.*

390. *Why is superphosphate of lime superior to phosphate of lime?*

Because phosphate of lime, which is derived from bones in their natural state, is *very difficult of solution,* and in a very dry season produces, in consequence, but very slight and imperfect effects. Superphosphate of lime, on the other hand, is extremely soluble, so much so that the vitriolized bones can be entirely dissolved, or suspended in water, and thus applied.*

391. *Why are dry bones more advantageous to vegetation than fresh?*

It is assumed that the removal of the fat and gelatine *facilitates the assimilation of the phosphate of the bone by the plant.* Nothing can afford a shadow of reason for saying that the animal matter of the bone is of *no use* to vegetation. On the contrary, we know that fat and oil, if extricated from bones, and applied to soil, act as potent manures, and

* W. C. Spooner.

that the gelatine is, in composition and effect, analogous to skin, wool, horn, &c.,—substances which contain a greater supply of nitrogen, which they afford the plant in the shape of ammonia, than any other animal manures with which we are acquainted.

392. At the same time it is possible that, by being applied together, the fat may *retard the decomposition of the gelatine*, and render the phosphates less soluble, and thus, in some cases, injure the efficacy of the application for the turnip-crop—which is of a quick growth, and requires a ready food in its early stages.*

393. It has been clearly proved that fresh bones *when ground* are superior to boiled ones, from which the *fat* has been extracted, and the latter superior to burnt bones, from which the *gelatine* has been also removed.

394. *Why is manure of boiled bones preferred by turnip growers?*

Because they are freed from the fat which *retards the decomposition* of fresh bones; at the same time they still *retain the gelatine*, which is so powerful an animal manure. So that—while their phosphates are rendered accessible to the plant by the fat being extracted (for boiled bones absorb water, and speedily decompose) they have in the gelatine an immediate supply of ammonia, and other organic food.*

395. *Why is the effect of bone manure so permanent?*

Because the bone-earth (phosphate of lime) is withdrawn from the soil by the crops *in small quantity only*, and continues to exercise a beneficial influence on the fertility of

* J. Hannam.

> "But formed elastic, with inclining shade,
> Their yielding stems each stormy gust evade
> So forest pines the aspiring mountain clothe,
> And self-erected towers the stately growth."—BROOKE.

the field to which it is applied for a considerable time. But the animal matter in bone-dust *decomposes and disappears* in great measure from the soil *in one or two seasons.**

396. *What has been the result of experimental investigation of the effect of bones applied in various forms to turnips?*

The result of a series of careful experiments upon the actual growth of turnips, under the influence of bone manures in various forms, proves that both the organic and inorganic parts of bones are fertilizers; that the TOTAL action of the inorganic is GREATER than that of the organic; that when applied in conjunction, the latter has a tendency to RETARD the action of the former; that this tendency may be counteracted by *pulverizing the bones*; that it may be *most effectually* accomplished by *dissolving the bones* in a *diluted acid*; that *sulphuric acid is best*; and that the fertilizing influence of the bones thus treated will be *quadrupled.*† THUS PRODUCING THE MOST IMPORTANT SAVING WHICH WAS EVER HELD OUT IN THE USE OF MANURE.‡

397. *What are the chief constituents of guano?*

The chief mineral constituents of *potash, soda, chlorine, sulphuric acid, and phosphoric acid* (the latter the most important), *are* FOUND IN GUANO. *Nitrogen,* the most valuable constituent of manures, is found in guano in *great abundance,* and in a condition adapted for vegetation.§

398. Guano is the excrement of sea-fowl, and was used as manure probably for ages before Peru was visited by the Spaniards. Along

* Professor Johnston. † J. Hannam. ‡ Mr. Pusey.
§ Nesbit "On Agricultural Chemistry."

> "Shall fields be tilled with annual care,
> And minds lie fallow ev'ry year?
> O, since the crop depends on you,
> Seek thou the culture which is due."—COTTON.

401. *Why is guano so very valuable as a manure?*

Its *peculiar nature* appears to find explanation in the opinion of many of our first practical chemists, to the effect that the value of different manures varies NEARLY IN PROPORTION TO THE AMOUNT OF NITROGEN THEY CONTAIN.

402. There may be cases to which this rule is not exactly applicable; but in many natural manures, an increase of nitrogen is accompanied by an increase of phosphate of lime, and *every other valuable element.*

403. If we take the per centage of nitrogen, as a correct indication of manuring value, we shall find that ONE TON of ordinary Peruvian guano is equal to:

☞ 33½ tons of farm-yard dung.
21 tons of horse dung.
38½ tons of cow dung.
22½ tons of pig dung, and
14½ tons of mixed human excrements.

404. LET THOSE WHO FARM IN HILLY COUNTRIES, AND OTHER PLACES WHERE CARRIAGE IS EXPENSIVE, PONDER WELL THE ABOVE FACTS.*

405. *Why are the effects of guano more immediate and decided upon some soils than on others?*

Because soils differ both in chemical composition and mechanical properties. The heavier in general contain more *alumina* and *oxide of iron* than the lighter ones. They are also *less porous*, even when drained; their particles are finer, and their *absorptive power is greater.* The want of great porosity *prevents the too rapid action of the atmosphere* on the manures they may contain, and their *absorptive*

* J. C. Nesbit.—See, however, Liebig's latest opinions.

power enables them to *retain, to a considerable extent, the liquid and volatile elements of the manure*, and at the same time to obtain a certain quantity at the expense of the atmosphere.

406. The case is, however, different with *gravels, sands*, and the lighter soils, upon which, in consequence of their greater porosity, the atmosphere acts freely, and to a considerable depth.

407. When manure is applied to them, it is rapidly decomposed, and, unless there be a growing crop ready to absorb the fertilizing particles as they become soluble, they will be washed away; or, if they become volatile, will, to some extent, be absorbed by the atmosphere. These soils, therefore, require different treatment. We may apply to heavier lands a strong dressing of manure at once, and little loss will ensue, for some time at least, from any other source than the action of the growing crops. On the lighter soils we must use, even of farm-yard dung, a *less amount at a time;* but it *must be applied more frequently*. We thus see that light lands have the advantage of more rapidly decomposing the dung, and, consequently, of preparing it more quickly for the use of the plant. For this reason, among others, light soils are preferred by the market gardeners, who, by their repeated manurings, and frequent croppings, practically show how these soils may be most efficiently managed.*

408. *Why, when applied as a manure, should guano be diluted by admixture with earthy ingredients?*

Because, like *rape-cake*, its action is *over-stimulating* to vegetable *germination*, and if it comes in contact with the seeds, destroys their vitality. It should, therefore, be finely pulverized, and mixed with five or six times its weight of coal ashes, turf, mould, or fine soil.

409. In an experiment made by Mr. Pusey, soon after the introduction of guano, it was applied to half an acre of ridged Swedes, at the rate of 3 cwt. to the acre, drilled under the seed. The first action of the guano

* J. C. Nesbit.

"Shot up from broad rank blades that droop below,
The nodding wheat-ear forms a graceful bow,
With milky kernels starting full weighed down,
Ere yet the sun hath tinged its head with brown."—BLOOMFIELD.

was discouraging; for, on one-half of the ground dressed with it, no plant came up. On transplanting into the blank spaces, the seed was found *encrusted with the guano, without any signs of vegetation.*

410. *Why do the Peruvian farmers prefer "fresh" guano?*

Because, next to the fertilizing effect of ammonia, or perhaps equal to it in value, is the *uric acid* which guano contains. The fresh guano is more valuable, chiefly because it contains more of this acid in an undecomposed state.*

411. *Why is guano calculated to fertilize a great variety of crops?*

Because it contains a quantity of *phosphoric acid*, in combination with *ammonia*, *soda*, and chiefly with *lime*. *Now all plants require for their healthy growth a portion of this acid in combination with lime.* The presence of these substances, therefore, enables the guano to *minister to a greater number of the wants of living vegetables* than it could do were it *entirely* composed of *uric acid*, or of *ammonia*. These latter compounds may abound about the roots and leaves of plants, and yet, if the phosphates be wholly absent, the plant which sprung up of a bright green, and shot forth with vigour, will never attain to a healthy maturity, or produce an adequate return of nourishing food.

412. The important influence of guano on the vegetation, equally of America and England, seems to depend upon two circumstances:—1st, on its containing a well-tempered mixture of a *great number* of those substances which the plant requires for its perfect growth or development; and, 2d, on this admixture including a *considerable proportion of ammonia*, which in a remarkable degree hastens the growth of the young plant, as well as *phosphate of lime*, which is necessary to its healthy and perfect maturity.*

* Professor Johnston.

"A field deep furrowed next, the god designed,
The third time laboured, by the sweating hind;
The shining shares full many ploughmen guide,
And turn their crooked yokes on every side."—POPE.

413. The general conclusion that may be deduced from the various experiments and tests to which guano has been subjected, is, that good *guano* will, under judicious application, increase crops of grass about THIRTY-THREE PER CENT., at a cost considerably under the average cost of all other manures, whether farm-yard dung and composts, or artificial compounds. Guano is, moreover, peculiarly adapted to horticultural and floricultural improvement, by its relative cleanliness and facility of application.*

414. *Why are woollen rags and flocks capable of fertilizing soils?*

Because they contain *ammonia;* in which respect they are nearly thirty-four times stronger than fresh cow dung.

415. Connected with flocks and wool, there is a very valuable product, rich in all the elements of manure, which is often lost, or not used, for agricultural purposes, namely, the sweat, or natural soap of wool. Fresh-dipped wool loses from 35 to 45 per cent. of its weight by washing. This is due to a peculiar matter exuded from the wool, and which consists chiefly of potash, lime, and magnesia, united to a peculiar animal oil, forming an imperfect soap. It is remarkable that this soap of lime, in all other cases insoluble, is here soluble in water. The experience of the best French agriculturists, is full of testimony to the good effects of this wool sweat. It has been calculated that the washings from wool, annually consumed in France, are equal to manuring 370,000 acres of land.†

416. For agricultural purposes, all animal and vegetable products may be divided into TWO CLASSES: 1. That which DOES contain *nitrogen*. 2. That which *does* NOT. The action of these is very distinct, as the elements of soil, and as manures. The *first class* PUTREFIES, the *second* DOES NOT. The first class forms *alkalies*, the second forms *acids*. The action of the first depends on NITROGEN, that of the second on CARBON. The first class contains *flesh* in all its varieties, *blood, skin, sinew, gristle, cartilage, tendons, hair, feathers, wool, hoofs, horns, nails, scales,* and nearly one-third of *bones and teeth.* The second class contains *fats* and *oils,* in *all their variety.*

* Dr. Ure. † Dr. S. L. Dana.

"While he broke up new ground, and tired his plough
In grassy furrows, the torn earth disclosed
Helmets and swords (bright furniture of war
Sleeping in rust) and heaps of mighty bones."—WATTS.

417. *Why does soot form a valuable manure?*

Because it contains several fertilizing elements, such as *charcoal*, *ammonia*, *muriatic acid*, *lime*, *magnesia*, and other substances. The chief matters contained in soot are the *produce of vegetation*, and are also the *natural food of plants*; the *carbon* gradually combines with the *oxygen* of the atmosphere, and is converted into *carbonic acid gas*, which is readily absorbed by the roots and leaves of plants.*

418. The effects of soot, when spread upon the surface, are discovered immediately after the first rain. It is likewise of use, from the saline matter which it contains, in *promoting the destruction of slugs*.†

419. Soot forms a capital liquid manure for the floriculturist. Mixed with water, in the proportion of six quarts of soot to one hogshead, it has been found to be *a most efficacious liquid*, with which to water *green-house plants*; and being not only an available but a comely preparation, it may *recommend itself to the cultivators of flowers*, by these desirable qualities.‡

420. *Why is the soot from chimneys, where the heat and draught are great, comparatively worthless, while that from ordinary chimneys is very valuable?*

Because the greater heat and draught *disperse the more volatile elements* of the soot, leaving the deposit more in the nature of *dry ashes*; the same causes *prevent the absorption from the air of those gaseous matters by which the properties of soot are improved.*

421. Good soot holds *ammonia*, *charcoal*, and other important fertilizers, and is used at the rate of 50 to 200 bushels per acre. Soot produces its greatest effects in *moist weather*, and in *dry seasons* it has sometimes *proved injurious*. It may be sown broad-cast over the field, and harrowed in, or mixed with such other manures in the

* Johnson's "Farmer's Encyclopædia." † Sir John Sinclair.
‡ Dr. S. L. Dana.

> "His lamp, his bow and quiver, laid aside,
> A rustic wallet o'er his shoulders tied,
> Sly Cupid, always on new mischief bent,
> To the rich field and furrowed tillage went."—PRIOR.

muck-heaps, as are intended for use. The *ammonia* has a great tendency to escape, which can only be prevented by adequate absorbents, such as *peat, muck, rich turf, tan bark,* or other vegetable remains. Many experiments made with it have proved *contradictory*, probably on account of differences of quality resulting from the *kind of coal* from which it was produced, the *dimensions of the chimnies*, and the intensity of the *draught and heat*. In some experiments it has been shown to be useless for *clovers*, while it has proved of great service to several of the *grasses*. It is more beneficial to *potatoes* than to *turnips*; and to *grain* than to *grasses* and *clover*, and other leguminous plants. *Salt*, when mixed with it, enhances its good effects. In an experiment made in England with potatoes, on three separate acres of land of equal quality, one with manure gave 160 bushels; one manured with 30 bushels of soot yielded 196; and the third which received the same quantity of soot, and seven bushels of salt, yielded 236.*

422. *Soot* is pretty extensively used as a manure, especially on farms overrun with game. It is believed to *protect the crop* in a considerable degree, by *rendering it distasteful to the game*. On asking a farmer the present price of soot, he said it was rather scarce in the neighbourhood, on account of a large demand from his landlord, who required it *for application to a farm overrun by game*.†

423. *Why does salt improve the action of soot?*

Because it absorbs moisture from the atmosphere, which moisture *assists the decomposition of the soot*. The great basis of soot is charcoal or carbon, which is capable of being rendered soluble *by the action of oxygen and water*.‡

424. *Why is it commonly said that "the land never tires of farm-yard manures?"*

Because farm dung contains within itself, not *one* alone, but ALL the ingredients which plants require for their nutrition, and what is perhaps of equal importance, *existing*

* R. L. Allen; J. Sheir. † Caird's Agriculture. ‡ Sir H. Davy.

"With all the ashes all thy coppers yield,
With weeds, mould, dung, and stall, a compost form,
Of force to fertilize the poorest soil."—GRANGER.

*in that state in which they are most readily taken in and assimilated by the vegetable organs.**

425. Farm-yard dung contains *all the principles withdrawn from the soil by the growth of plants:* the decomposed straw furnishes *silica* in a minute state of division still having with it a little *potash* and various saline substances; the solid animal excrements contain abundance of *earthy phosphates;* while the *urine* gives up by its putrefaction at once *carbonate of ammonia* and more *phosphate,* besides smaller proportions of other principles. The only thing at all defective is *potash,* and that frequently *exists plentifully in the soil,* and is gradually liberated by disintegration.†

426. *Why is manure produced by young stock less valuable than that obtained from old?*

Because young animals require *phosphoric acid, lime,* and *nitrogen,* for the *formation of bone,* and it can only be *from the food* that they obtain them. The excrements of a young beast, therefore, *cannot contain so much of these materials as those of a full-grown one*—a deficiency which one would suppose must be felt when they are applied to crops such as *wheat, barley, beans, clover,* and *turnips,* which require *much phosphoric acid, lime,* and *nitrogen,* for their perfect development.

427. For the formation, too, of the bodies of young animals, besides these three substances, there is much *carbon, hydrogen, sulphur, chlorine,* and *soda,* required: and as the whole of these elements are *abstracted from the food* by the digestive functions, it is easy to be conceived, that *since they are all requisite for the nourishment of plants,*

* Dr. Daubeny.
† Dr. Fownes.—See also Liebig's views, at the close of this Section.

especially for nutritious plants, *the excrement of young animals can never have so great a value as that of full-grown stock*, as the latter retain so much only of the substances in question as is necessary to repair waste and expulsion.*

428. *Why do the qualities of animal manures differ?*

Because the *kind*—the *organization*—of the animal, affects the value of the excrement, inasmuch as some of them seize upon or reject this or that particular element of the food, and retain it in the body, or excrete it.

429. *Cows*, for instance, require, for the chemical constitution of their bodies, or for the formation of milk, *more nitrogen* and *phosphate of lime*, &c., than *sheep*; and the latter require again more *sulphur, common salt*, &c., for the formation of their *wool*; the excrements of *oxen*, consequently, cannot contain so much *nitrogen* as those of *sheep*, while they are more abundant in *salt* and *sulphur*. Partly, however, the value of the excrements of different kinds of animals *depends on their digestive organs*, as well as on the finer attrition of the food in the process of chewing. Sheep, having *stronger digestive organs* than cows, on that account *exhaust their food more completely*, and they are also able to abstract from it more nutriment, in consequence of *the finer state to which they reduce it in chewing. With food, therefore, of the same kind, the excrements of sheep cannot be of so much value as those of oxen*; if they act more quickly, this arises from their being sooner decomposed, in consequence of being more finely divided. Experience, indeed, teaches us that sheep manure produces its effects *more speedily*, but by no means so *permanently* as the manure of oxen.*

430. *Why does the mode of employment of animals influence the nature of their excrements?*

Because it affects *the different secretions* of their bodies,

* Translated from Professor Spregnel's "Theory of Agriculture," and founded by the author upon ten years' practical researches.—Journal of Royal Agricultural Society, Vol. I.

"Dry fern, or littered hay, that may imbibe
Th' ascending damps; then leisurely impose,
And lightly, shaking it with agile hand
From the full fork, the saturated straw."—COWPER.

causing the extraction from their food of more or less of the elements expended by the modes in which they are employed.

431. Cows *which are milked* cannot furnish excrements of so good a quality as cows *which are not either in milk or in calf*, for substances must be supplied *for the production* of *the milk* and *for the growth* of *the young* in the body of the mother, which the food has yielded, and *these are the very substances which are the most powerful as manures*, namely, *nitrogen*, *sulphur*, *phosphorus*, *chlorine*, and *soda*.

432. Draught-oxen (in Germany) which remain quiet in the stall during the winter, when fed in the same manner as cows, always give *better dung* than the latter, provided they are not improving in condition; for if they are improving, then the food *helps to form flesh*, which contains almost the same substances as the *milk* does.

433. *Wethers*, under similar circumstances, give better manure than *ewes*, for the former produce only *wool*, while the latter furnish *also milk*, or nourishment for the lamb, for which the food has yielded the materials.

434. Since the materials of the food, therefore, are differently appropriated in the formation of *wool*, *flesh*, *fat*, *bones*, and *milk*, and since the excrements result from the food, it is very natural to suppose that the different employment made of the animals, must have a considerable influence on the value of their excrement.*

435. *Why does the kind of food given to animals influence the value of their excretions?*

Because, when animals are so badly kept that they daily lose flesh, their excrements also become *lowered in quality* in the same proportion, since the body, in such case, not only *expels fewer of its own worn-out particles*, but the food itself becomes *more exhausted by the digestive organs.* If, on the contrary, the animals are kept on abundant and nourishing food, their excrements are *very strong in quality*, for these

* Professor Spregnel.

"Ah! Gaffer Pestel, what brave days were those
When higher than our house our muck-hill rose."—JAGO.

will not only contain much refuse animal matter, but the food itself also is *less exhausted.*

436. Hence the manure of *fattening stock* is the BEST. Animals immoderately fed give *most powerful manure,* with the disadvantage, however, that the food *has not undergone a proper change.* Accordingly, the more nutritious in general the food is, the better are the excrements resulting from it, supposing the animals to obtain so much of it, as to gain instead of losing flesh, and fat; for the excrements resulting under these circumstances are abundant in *phosphorus, sulphur, soda, potash, chlorine, lime, magnesia,* and *nitrogen.*

437. Fattening stock, as we learn by experience, yield very strong manure *when they are allowed the free use of salt;* and this is natural, for, by the addition of the salt, *the manuring substances are increased.* It is likewise maintained that the excrements of oxen fed on *scalded fodder* are of superior quality to those of stock fed in the ordinary manner: this, however, is scarcely possible; they must, on the contrary, with equal quantity and quality of food, be inferior, for, by the process of scalding, *the materials are so prepared for the digestive organs as more easily to yield their best portions to them.*

438. For this reason, we give *cows* a less quantity of the scalded fodder than of that which has not been so prepared. The excrements of *oxen* fed on scalded food *come sooner into effective operation,* since the *woody fibre* and the hardened vegetable portions of the food are *softened* by the process of scalding, and, consequently, when in a state of excrement, are *decomposed more rapidly.* On account of this *quicker effect,* the excrement of cattle fed on scalded food *is supposed to be the best,* though IT IS NOT REALLY SO.*

439. *Why ought not solid animal manures to be allowed to putrefy in heaps above ground?*

Because a great proportion of the manuring matter, in that case, assumes the *state of gas,* and is wasted. Professor Gazzeri, of Florence, found from experiments on a small

* Professor Spregnel.

"Money is like muck, not good except it be spread."—BACON.

scale, made expressly to ascertain this fact, *that solid excrements of cattle, undergoing putrefaction in the open air, lost 5 per cent. of their substance in forty days.*

440. Now, although in this respect the case of excrements which lie in manure pits is somewhat different, as *the oxygen of the air has less free access* under these circumstances, there was in Gazzeri's experiment a waste sufficiently great to show that *it is not profitable either to allow the excrements to lie long in manure pits, or to employ them as a top-dressing.* They are, however, seldom made use of alone, but generally mixed up with straw and urine into common yard-dung, and in that state applied to the field.*

441. *Why does ammonia become developed during the process of fermentation?*

In the heap, previous to fermentation, the *nitrogen*, the essential element of *ammonia*, and of supreme value to the farmer, is variously combined with *carbon*, *oxygen*, and *hydrogen;* but when it leaves its former arrangement, in obedience to the action of the decaying bodies, *it uniformly adopts one, and only one new one.* Every nitrogenous compound exposed to air and moisture *liberates its nitrogen to unite with free hydrogen and form* AMMONIA. *This is a principle of fermentation which admits of* NO *exception.*

442. We are acquainted with no instance in which the nitrogen of organic compounds, fermenting under those conditions, combines with oxygen, *until it have first formed* AMMONIA with *hydrogen*; but *after* the formation of *ammonia*, *oxides of nitrogen* are formed with facility.

443. This is a well-known cause of difficulty in nitrogen determinations in organic analysis; and it brings before us the important fact that *before the farmer can obtain any*

* Professor Spregnel.

nitrates for his crops, he must incur RISK OF LOSS *by the formation of* VOLATILE AMMONIA. *Does it not also press upon him the wisdom of taking all possible precaution to conserve the latter, that by its oxidation in the presence of lime and other alkaline bases, his fields may be supplied with abundance of the former?**

444. *Why do dung-heaps emit a peculiarly pungent odour?*

It is a prevailing opinion among farmers that the peculiar smell which emanates from dung heaps *is caused by the escape of ammonia.* But the very powerful smell is due to the escape of peculiar volatile organic combinations—to *sulphuretted* and *phosphoretted* hydrogen, and a great variety of gaseous matters, *among which there is ammonia in minute quantities.*

445. From these products of putrefaction, ammonia can be completely separated without in the least destroying the peculiarly offensive smell which emanates from organic matter in decomposition. If, for instance, *dilute sulphuric acid* is added to farm-yard manure, or liquid manure, the smell of these substances, instead of becoming *neutralized,* becomes more offensive. Any *free ammonia* would, by this treatment, be fixed as *sulphate of ammonia;* but the smell continues, and it arises in a great measure from the liberation of *sulphuretted hydrogen.*†

446. *Why is there comparatively little smell when dung-heaps are closed?*

Because the gases *generated by fermentation in the middle of the heap,* are *cooled, condensed,* and *absorbed by the*

* Rev. W. R. Bowditch. † Dr. Voelcker.

"The chalky cliffs salute their longing eyes;
Each to his breast, where floods of rapture roll,
Embracing strains the mistress of his soul."—FALCONER.

external layers, and become *fixed in the heap*, provided the rain is prevented from removing the soluble matters, and with them, the ammoniacal salts..

447. In relation to the amount of ammonia, farm-yard manure always contains a great excess of these humus acids, *by which it is fixed*; hence the *free ammonia*, proceeding from the interior portions of dung-heaps, which are in a state of fermentation, is arrested by the humus substances contained in the cold external layers of the heaps. In contact with air, any undecomposed straw is gradually changed into these excellent fixers of ammonia, and thus a natural provision is made to prevent the loss of that element.

448. Nobody can deny that farm-yard manure is *seldom kept in the most efficient manner*. In many places in England, especially in Devonshire, and in parts of Gloucestershire, it is a common practice to place manure-heaps by the roadside, often on sloping ground, and to keep these loosely-erected heaps for a considerable length of time before carting the dung on the field. On other farms, the manure is allowed to remain *loosely scattered about* in uncovered yards for months before it is removed. Heavy showers of rain falling on manure kept in such a manner, by *washing out the soluble fertilizing constituents of dung*, necessarily greatly deteriorate its value. It is well known that the more or less dark-coloured liquids which flow from badly-kept dung-heaps in rainy weather, possess high fertilizing properties. According to the rain which falls at the time of collecting these drainings, according to the character of the manure, and similar modifying circumstances, the composition of the drainings from dung-heaps is necessarily subject to great variations.*

449. For the preparation of farm-yard manures, it is highly important to understand *the indication of their fermenting condition*. If the fermentation which has occurred through the depth of the manure has *sufficiently broken its fibre*, so that it could be at once ploughed in; *if its temperature be below* 100°; if there be *a smell of ammonia* when it is lifted by the prong; or, as a chemical test, if *reddened litmus-paper*, when held for a few minutes over it, *becomes blue*, and, after being gently heated, the blue tint disappear: *in neither of these cases*

* Dr. Voelcker.

"Conversation, in its better part,
May be esteemed a gift, and not an art;
Yet much depends, as in the tiller's toil
On culture, and the sowing of the soil."—COWPER.

should the manure on any account be moved or turned up ONE MOMENT *before it is carted to the field for the purpose of being at once ploughed in.*

450. If the animals from which the manure has been chiefly derived *have been fattening*, and a fair amount of litter has been used by those loose in the yards, the state described above will usually be found to exist about the latter end of April or May, supposing the manure to have accumulated since December. If no cattle have been loose in the yard, the decay will have been much more rapid, and an important loss, both of bulk and matter, will be the consequence, unless artificial means, such as *pressure*, the *mixing of sawdust, earth*, or *ashes* are used to prevent it.

451. When, however, on its condition being tested, the straw is found to retain *nearly its original texture*, and to be merely saturated with water; when no ammoniacal vapours arise from it, and when, on exposure to the air for a short time, it resumes its original strawy character, with the exception of limpness and loss of colour, then it is necessary that it should be at once thrown up into heaps of a convenient size, as lightly as possible, that it may be stimulated to ferment. If this operation should be found not to proceed fast enough, the addition of a little water will hasten the decomposition; or, if it should proceed too fast, compression and covering with earth, &c., will tend materially to postpone it.*

452. The true economy of farm-yard manures may be thus indicated:—*nothing must be allowed to run away in the form of a fluid, or to fly away in the disguise of a smell.* * * * Mark out a piece of ground on which the dunghill is to be made, on a good slope, if possible, and close by a pond. Cut a gutter all round, and puddle it with clay, so as to make it water-tight. Then, at the lowest part, outside the place where the dunghill is to lie, dig a sink-hole eighteen or twenty inches deep; let this be well puddled, and connected with the gutter already spoken of. Things being thus prepared, throw down a layer of manuring substances, about a foot deep; tread them well down, and scatter some fixer over it;—finally, water it well. In this manner go on, with layer after layer, till the heap is the desired height. * * * During the operation of making

* E. O. Squarey, Odstock Farm, Salisbury.

"Each grain and seed, consumed in earth,
Raises its store, and multiplies its birth,
And from the handful, which the tiller sows,
The labour'd fields rejoice, and future harvest flows."—PRIOR.

the heap, some water will have drained away; in that case, it will have run into the gutter, and been collected in the sink-hole. Scuppet the water out, as the work proceeds, and throw it back on the dunghill. If the hole is not large enough, another can be made near it. None of the drainings *must on any account be lost*. It should have, at least once a week, for a month, a good quantity of fluid thrown upon it. Pot-boilings, and soap suds, are much better than common water; but *urine* is preferable to both. * * * By these contrivances nothing is allowed to leak, but the dunghill becomes a soft mass, holding fast all that belongs to it, except what flies away. To *catch the latter* is the *purpose of the fixer*. There are many kinds of fixers,—oil of vitriol, green vitriol, blue vitriol, salt *and* lime (not either salt *or* lime by themselves, on any account,) gypsum, &c., may be used; but some of them at all times, and in some cases all of them, have the fault of costing money. A substitute which *costs nothing except labour* is, therefore, to be sought for. Such exists in *cinder-siftings, charcoal dust*, good *black earth, peat* or *bog mould, rotten sawdust, leaf mould, black mud* from ponds, *bottoms of wood stacks, soot, brickdust, burnt clay*, &c. Some or all of these may be had in most places.*

453. *Why will the admixture of manure in a state of fermentation facilitate the decomposition of fresh manure?*

It is to be borne in mind that the substances to be changed are composed chiefly of *carbon, oxygen, and hydrogen*, of which the last element is the *most prone to decomposition*—that is, to enter into new combinations. *Wherefore, as soon as one decomposing nitrogenized substance communicates to a sound one the state of change in which its own elements are placed, the elements of that other body, partaking of the disturbance, begin to be liberated, and the freed hydrogen seizes with avidity upon any oxygen in its neighbourhood, and forms water.* The liberation of one element is the liberation of others, and the carbon now seeks oxygen, whereto it may be allied in the form of carbonic acid.

* Dr. Lindley, in the "Gardener's Chronicle."

"The grassy lane, the wood-surrounded field,
The rude stone fence with fragrant wall-flowers gay,
The clay-built cot, to me more pleasure yield
Than all the pomp imperial domes display."—SCOTT.

454. When a *rotten apple* is mixed with a quantity of *sound ones*, the parts of the latter which are in contact with the former, are *altered in condition*, and begin to decay. This well-known fact creates a necessity for constantly examining kept fruits, and removing those which show any symptoms of rottenness. It is further known, that *when once an apple is affected*, the ENTIRE SUBSTANCE *soon undergoes decomposition*. Thus the putrefaction of manure is begun and propagated. Substances which are in themselves in a state of putrefaction aro brought into contact with others which are not, and communicate by contact their own state of change, and hence the action is *propagated from one particle to another throughout the heap.**

455. *Why do organic bodies undergo decomposition?*

Because the elements of which they are composed, *being no longer held together by* VITAL *influence*, become *affected by* CHEMICAL *agencies*, and SEPARATING FROM THEIR PRESENT UNION, *enter into* NEW FORMS and COMBINATIONS. These separations and re-combinations occur in all the processes of "*rotting*," "*heating*," "*sweating*," "*fermenting*," "*steaming*," "*charring*," "*moulding*," "*decaying*," "*putrefying*," "*stinking*," &c., with which the farmer is familiar.

456. The process of DECOMPOSITION, or the *separation of two substances chemically combined*, is a very interesting and important chemical operation. It is by *decomposition* that wood or coals, when they are burnt, are *separated into a light, transparent gas*, which flies away, *and the gray or white ashes* which remain; it is by *decomposition* that *dead vegetables are separated into a light airy matter*, and a *black powder* or *charcoal*, which remains in the soil, and gives the very dark or black appearance to soils which contain much peat or turf; and it is the *decomposition* of such dead vegetables that, in a manner, grinds them down,

* Rev. W. R. Bowditch.

"'Midst thy paternal acres, Farmer, say
Has gracious heaven bestowed one field that basks
Its loamy blossom in the mid-day sun:
There shalt thou plant the hop."—SMART.

so as to be in a fit state for *affording nutriment to new generations of plants.*

457. This *separation* of substances which are *combined* is effected, *either by bringing in contact with them a substance which has a* VERY GREAT ATTRACTION *for* ONE *of them* or sometimes by *simply* HEATING *them*; is taken advantage of in a thousand different ways in the arts and manufactures; and is the leading feature in many natural processes going on at the surface of the globe.

458. The grand agent in bringing about all these changes, is *chemical attraction;* and the operation of this power gives rise to two kinds of action, DECOMPOSITION and RECOMBINATION; in these two changes almost all chemistry consists.

459. WHEN IT IS UNDERSTOOD THAT THERE ARE DIFFERENT KINDS OF SUBSTANCES ON THE EARTH, THAT THESE DIFFERENT BODIES HAVE A DISPOSITION TO UNITE WITH EACH OTHER AND FORM NEW VARIETIES, AND THAT THEY HAVE NOT ALL AN EQUALLY STRONG ATTRACTION FOR EACH OTHER, BUT THAT ONE SUBSTANCE WILL SOMETIMES LEAVE A BODY WITH WHICH IT IS UNITED, AND UNITE WITH ANOTHER IN PREFERENCE; WHEN THESE FACTS ARE BORNE IN MIND, WE HAVE A CLUE TO THE WHOLE PHENOMENA OF CHEMISTRY.*

460. *Why, in the fermentation of dung, is a large quantity of water formed?*

Because of the strong affinity of *hydrogen* for *oxygen*—these two elements uniting form water. A large quantity of ready-formed water is thus added to the solid excrements of animals, and the sum of this existing and generated moisture is increased by the rain-fall. Yet we see every heap, made of *horse-dung alone,* burnt, and often those of an ill-managed farm-yard are in the same condition. What renders this case more noticeable, is, that the burning is the worse when the evaporation is the greatest, and no

* Reid's "Chemistry of Nature."

> "If thy strong loam superfluous wet retain,
> Lead through thy fields the subterraneous drain,
> And o'er the surface mellowing stores expand
> Of fiery lime, or incoherent sand."—SCOTT.

spectacle is more familiar to an observer of the fermentation of manure than *a cloud of white vapour, which completely conceals the workmen who are removing a heap of "fire-fanged" horse dung.*

461. *Every particle of that exhaling moisture was designed by a beneficent Providence to be condensed into a liquid, charged with the precious burden which it is now bearing away on the wings of the wind.* ELEMENTS OF CORN AND CATTLE ARE VOLATILIZING WITH EVERY GLOBULE OF THE STEAM, and (in towns) are becoming *sources of disease and death to those whom, if differently managed, they might feed!* And why? Simply because *man* WILL defeat Nature. Nature designed putrefaction to be SLOW, and to that end required all decomposing refuse to be buried, in which case its slow but useful conversion was certain. Man, on the other hand, places the waste substances so that decomposition may be RAPID. He employs the light porous material—straw—to mix with urinal excreta, and places the whole so as to ensure a *free passage of oxygen* among the putrefying mass. The rapid burning of sticks is ensured by their being laid lightly across each other, so as to afford the readiest access to the atmospheric oxygen; and this is a close approximation to the state of dung thrown lightly into a pit. The heat generated during its combustion converts the water of the burning wood into steam, which passes freely and rapidly up the chimney, and that of dung may be seen, on a still, dewy morning, forming a column of some twenty feet in height above its source.*

462. *Why do the excrements of horses develope so great a heat, and give off such a pungent odour?*

Because, being generally *fed with corn,* their solid excrements contain *many substances having nitrogen as an element,* and this circumstance *explains their rapid and perfect fermentation.* This, and the smaller amount of water contained in them than in the excrements of cattle, is the

* Rev. W. R. Bowditch.

"For man of soule reasonable
Is to an angell resemblable,
And like to beast he hath felyng,
And like to trees he hath growing."—GOWER.

combined cause of the *great heat*, and the escape of a *large quantity of ammonia*, in the shape of gas.

463. When horse dung lies in large heaps, it undergoes a *very quick decomposition*, becomes *heated*, *steams*, and developes much *ammonia*, *carbonic acid*, *carburetted hydrogen*, and, when the heat increases, also *carbonic oxide*, finally passing into a *half-carbonized state*, and becoming *mouldy*; in consequence of which, a great loss of manuring matter—equal to 9½ per cent. of the solid mass in the course of two months—takes place, whence it is evident how injudiciously we act when we allow horse manure to lie for a long time in heaps at the stable door.*

464. *Why, if we manure a field of growing plants with fresh horse dung, do the plants turn black, and appear charred?*

This, which frequently happens, *arises from that portion of the ammonia produced from the dung which has not been neutralized.* This blackening of plants is erroneously regarded as the effect of smut; it is most likely to happen when a soil very deficient in humus has been manured with horse dung. In order, therefore, that *none of the ammonia may be lost in the form of gas*, it will always be found the most advisable to *apply fresh horse manure where the soil is richest in humus*; for the manure has, *in that case*, a beneficial effect on the component parts of the soil in *rendering the humic acid more soluble.**

465. *Why is pig dung regarded by farmers as a "cold" manure?*

Because it contains *a large proportion of water*, and but *little nitrogen*, and therefore is slowest to undergo decomposition. This arises from the *miscellaneous nature of their food*, and the fact that their digestive organs being very

* Professor Spregnel.

'And here I draw my heaps of finest mould,
Mixing half quantity of dung that's old,—
Esteem'd by husbandmen like hoards of gold."—LAWRENCE.

powerful, *they exhaust the substances* upon which they are fed. Only when they are very highly fed, for purposes of *fatting*, does their manure become of any value. Pig dung developes very little heat while undergoing putrefaction, and yields but little ammonia.*

466. *Why do esculents, when manured with pig dung, acquire a very disagreeable flavour?*

This arises from a substance, *peculiar to the excrements of the pig*,—a volatile excrement—at present imperfectly known.*

467. *Why are the excrements of pigeons and fowls more potent as manure than those of geese?*

Because the former live chiefly upon *grain*, *insects*, and *worms*, while geese eat largely of *grass*.

468. *Why should the yards and houses where pigeons and poultry are kept, be strewed with some soil abundant in vegetable mould?*

Because their excrements are very rich in *ammonia*, which has a tendency to escape. The *humus* of the soil, however, would *absorb and fix it*. Strewing the ground with sand and sawdust, as commonly practised, is of no use whatever.*

469. *Why do the droppings of geese, which come in contact with grass, destroy it in a short time?*

Because the *uric acid* and *ammonia* which the droppings contain are highly caustic. *When rain happens to fall*, these

* Professor Spregnel.

"There Honour comes, a pilgrim gray,
To bless the turf that wraps their clay,
And freedom shall awhile repair,
To dwell a weeping hermit there!"—COLLINS.

caustic subtances are *diluted*, and the grass grows best in places where the excrements lie, as may be seen in any goose pasture.

470. *Why does sheep dung come into more immediate action as a manure, than the dung of cattle?*

Because sheep dung *consists of more finely divided parts*. It also contains more of the *easily decomposable substances containing nitrogen;* for while the solid excrement of *cattle*, in 1000 parts of weight, contains only from 105 to 112 of substances that are quickly decomposed, that of *sheep* contains no less than 180 such parts.

471. If we consider that sheep dung *consists of very finely divided parts*, in consequence of the minuteness to which sheep chew their food, we shall easily understand how it happens that it *comes sooner into action than the dung of cattle*, and whence it arises that when lying in heaps, *it becomes so much heated*.

472. The excrements of the *cow*, when fed on green spurry, contain 15 or 16 per cent. of vegetable fibre, while the excrements of *sheep* fed on hay contain only 14 per cent. of that substance; now, as the amount of water in cattle dung is about 4 per cent. greater than in that of sheep, and since the proportion, therefore, of vegetable fibre ought to be the largest in sheep dung, we may draw the conclusion, as before, that *sheep digest a portion of the vegetable fibre itself*.

473. From the pulpy nature of cattle dung, and the firmer character of sheep dung, we might, indeed, conclude that the difference in the proportion of water they each contained would be greater than 4 or 6 per cent.; but the vegetable fibre being in a finer state in sheep than in cattle dung, it is capable of retaining more water within its interstices *without such additional water being obvious*. Now, although the excrements of the sheep undergo a quicker decomposition than those of cattle, this does not take place in the ordinary mode in which the sheep

manure is obtained, there being a deficiency in the moisture requisite, and the dung so firmly trodden down by the sheep, which is not tied up like the ox, that oxygen, which is essential in every case of quick decomposition, can gain no entrance: accordingly, in sheep manure which has lain perhaps a year or more in the sheep-house, we always find solid excrements *in which scarcely any change is perceptible.*

474. All the products which arise from the putrefaction of the solid excrements of cattle appear also on the putrefaction of sheep dung; the latter, however, also yields much *ammonia*; hence it is obvious that sheep dung must contain more substances with nitrogen for an element than cow dung does; and this is exactly the reason why sheep dung so quickly passes into decomposition.

475. In cattle, the substances containing *nitrogen*, which are secreted from the body of the animal, occur more in the *urine;* but we might almost imagine that, with the same food, the fluid and solid excrements of the *sheep*, taken together, would possess more substances containing nitrogen than are contained in the whole of the excrements of cattle, since the former develope, as it appears, a rather larger quantity of *ammonia* than the latter.*

476. *Why are liquid manures, in some material points, more economical than dry manures?*

Because, if manures are kept in a sufficient quantity of water, so as to become *thoroughly amalgamated with it by fermentation*, the whole *process of decomposition* is accomplished *before the manure is placed in the ground;* and, provided ordinary care be taken to *prevent loss by evaporation*, EVERY PORTION OF THE MANURE IS SECURELY CONFIDED TO THE SOIL. In the *solid* form, *on the contrary*, the act of decomposition takes place, partly in heaps in the farm-yard, but chiefly in or upon the ground, and *unless immediately succeeded by heavy rain, or completely covered with soil*, A CONSIDERABLE WASTE OF VOLATILE SALTS MUST ENSUE.

* Professor Spregnel.

"Digested heaps of miscellaneous mould,
Exposed to summer's heat, and winter's cold,
Enrich the native earth, and make it light,
And all its fermentations expedite."—LAWRENCE.

477. It is another important desideratum that the plant should find in the soil *a regular supply of food during the whole period of its growth,* and that it should not be *over-fed* at one stage of its existence, and *starved* at another. Hence the necessity of providing that the soil about the roots should *contain a fund of manure, or manure-producing substances,* in such a condition as to maintain a regular and even supply, until the plant has reached maturity, or a further quantity can be placed in the soil. It is essential to the perfect action of the manure that the process of decomposition of the undissolved particles should CONTINUE IN ACTION, and the storage of dissolved manure be maintained, at least as long as the crop to be fed remains in the ground. It has been thought by some *that this is not the case with liquid manure,* and the conjecture is sometimes correct in the case of a LIGHT SOIL dressed with *urine;* but practice, as well as the valuable experiments of Professor Way, declare that *an application of liquid, or liquefied manure, deserves a higher character for permanence of effect, especially on clay soils, than has usually been accorded to it.**

478. *Why does comparatively little benefit result from the application of liquid manures to stiff soils?*

Because such soils generally abound in *all the mineral matters which are required by cultivated plants,* and ALSO contain *an appreciable quantity of nitrogenized organic matters,* in comparison with which the fertilizing constituents of *liquid manures* are altogether insignificant. Such soils, moreover, possess in a high degree the power of *absorbing ammonia* from the atmosphere, and retaining it; and, in addition to this ammonia, *under good cultivation,* the vegetable remains left in the soils in the shape of *roots* and, *leaves* from the former corps, yield plenty of *organic food for plants.*

479. It is true that stiff soils are not always very productive; but, generally speaking, they contain within

* R. Dymond.

"The foe, the victim, and the fond ally
That fights for all, but never fights in vain,
Are met—as if at home they could not die—
And fertilize the field they each pretend to gain."—BYRON.

themselves all the elements of fertility, *and it is only for want of proper cultivation that their productive powers are not fully developed.*

480. Moreover, all clay soils are generally *more than sufficiently wet during the early part of the year;* the additional quantity of water supplied in liquid manure, renders them wetter still; and as much heat is absorbed during the evaporation of water, the injury done to the land by the resulting cold would not, I amagine, be counterbalanced by the small proportion of fertilizing matters supplied.

481. Again, clay soils, whether fertile or barren, and all land that is moderately stiff, like the majority of soils in England, must, by a heavy dose of liquid manure be rendered closer. Such soils certainly would not be improved in their physical character by an excess of water. The use of liquid manure, at a time when such land is more than sufficiently wet, is therefore objectionable. It is equally objectionable when stiff soils get too dry. In summer, soils of that description crack in all directions, and the liquid manure then *runs through the cracks* instead of passing through the soil, or it moistens the soil but very imperfectly. Much of the liquid manure is thus lost, and, moreover, injury is done by the insufficient proportion of manure that is absorbed by a thin layer of the surface soil, for it causes at first a more rapid development of the young plants, which receive a sudden check as soon as the small quantity of moisture is all evaporated.*

482. It will be observed that there is a difference of opinion between Dr. Voelcker and Mr. Dymond,—both very respectable authorities,—upon the adaptability of *liquid manures* for *stiff soils.* Probably the question at issue depends more upon the *chemistry of the soil,* than upon the *tenacity,* upon which Dr. Voelcker lays so much stress.

483. *Why is putrid urine one of the most valuable manures?*

Fresh urine contains some three per cent. of a white, soluble, crystalizable substance, called "*urea,*" which, on contact with water and the mucous matter contained in the

* Dr. Voelcker.

"Mean is the taste of all enjoyments here
Where reason does not act as arbiter."—LAWRENCE.

urine, undergoes, under the influence of this means (which acts towards it, in all probability, in the same manner as yeast does towards sugar), a peculiar change, or *fermentation*, whereby it becomes converted into *carbonate of ammonia*, and in that state is taken up and assimilated by the plant. It furnishes, in short, the same substance as the atmosphere,—the food of plants provided by nature herself. Moreover, urine contains a large quantity of phosphates, bodies indispensable to vegetable life.*

484. *Why, in manuring growing plants with urine, should we take care that it is free from admixture with solid excrements?*

Because they occasion on the leaves an incrustation which injures their growth; with this further evil, that the plants are thus *rendered loathsome to cattle.*

485. One of the uses of *manuring with urine*, which has hitherto been little regarded, consists in this, that *earth-worms* and the *larvæ*, or *grubs*, of *various insects*, which, in many countries, do such extraordinary injury to the *young rye*, are DESTROYED BY IT; this effect is produced, as my own experiments, made expressly on this point, have shown, by the *ammonia of the urine;* for, if we water a field much infested with earth-worms, with a solution of carbonate or caustic ammonia, the worms come immediately to the surface, writhe for some time, and then die. Probably, also, the *cockchafer grub*, when not too deep in the ground, might be *destroyed in the same manner;* a fact that would be of great importance to many districts.†

486. *Why should urine be diluted before being applied as a manure?*

Because it has been found that the diluted liquid contains

* Dr. Fownes, "On the Food of Plants."—Journal of the Royal Agricultural Society.

† Professor Spregnel.

"The fields, which answered well the ancient's plough,
Spent and out-worn, return no harvest now;
In barren age, wild and unglorious lie,
And boast of past fertility."—COWLEY.

nearly four times as much ammonia as urine left to putrify in its natural state, though it retained only 0·4 less of urea.*

487. *Why has the fresh urine of cattle a yellow colour?*

This is due to the presence of *a resinous matter*, secreted by the kidneys of the animals. On standing a long time exposed to the air, the urine assumes a brown, and, at last, a black colour. These changes may be ascribed to the formation of *humic acid* from the organic bodies which are passing into decomposition.†

488. *Why is the urine derived from cattle in summer, a better manure than that which they yield in winter?*

Because, in *summer*, fresh urine of cattle *always contains ammonia;* while, in *winter*, it DOES NOT *contain a trace of it.* In hot weather the urea, which is the principal source of ammonia, *undergoes decomposition* while remaining in the animal body.

489. Urine, which has been exposed for a year and a half in contact with the air, no longer contains any organic remains, but salts only, or mineral bodies dissolved in water; and as it is still endued, nevertheless, with strong manuring properties, *this proves that we must reckon minerals among the real means of food for plants?*†

490. *Why, when fresh urine is applied to plants, does it cause in them a sickly condition?*

Because of the *excess of caustic ammonia* which the fluid contains, the *urea*, too, ought to bear a *part of the blame,* since it is very difficult for plants to assimilate organic matters *unless such matters be dissolved in a large quantity of*

* R. Dymond. † Professor Spregnel.

"The coarse lean gravel on the mountain sides,
Scarce dewy beverage for the bees provides."—DRYDEN.

water. For this reason we allow the urine to *become putrid* before making use of it, in order that the urea may be decomposed, and the caustic ammonia converted into the state of carbonate, muriate, or acetate of ammonia.

491. The caustic ammonia arising in every case from the decomposition of urea and the other organic bodies of urine which contain nitrogen, remains partly dissolved in water, and is the substance through which urine, not properly putrefied, is so apt to injure plants.

492. *Why does putrefying urine emit a peculiarly pungent odour?*

493. Because in summer the urea, mucus, and albumen, held in solution in the urine, pass very quickly into a state of putrefaction, and much *ammonia* is developed *in the form of gas*; likewise *carbonic acid*, and a portion of *sulphuretted hydrogen*, which likewise partly assume the gaseous state. *The last two gases are the chief cause of the peculiar odour.**

494. *Why does the putrefaction of urine modify and improve its effects?*

Because, when the urine remains a long time exposed to the air, the *caustic ammonia* absorbs from it *carbonic acid*, BECOMES MILD, and is *then* adapted as a manure for vegetation. *Urine which has been putrefying for a month contains more than as much again of ammonia as urine in its fresh state*, and the ammonia is then chiefly in a combined and *mild state.**

495. *Why does the admixture of water with urine which is left to putrify, give an increased quantity of ammoniacal manure?*

Because the ammoniacal gas *has a strong tendency to escape*

* Professor Spregnel.

"The richest soil is most to weeds inclined,
And plants delicious thus are undermined;
Strangers—we know not who, nor whence they come,
Insult the natives in their proper home."—LAWRENCE.

during the putrefactive process. Now, water *absorbs this gas;* if, therefore, the urine is mixed with an equal quantity of water, *it is enabled to absorb more than as much again of ammoniacal gas,* and NO FURTHER ESCAPE OF GAS TAKES PLACE, at least in no considerable degree, provided the liquid be *kept in a cool place.* Thus DOUBLE THE QUANTITY of ammoniacal liquor is obtained.

496. There is another advantage: the larger quantity of liquid is now able to retain *more of the carbonic acid* developed within it, and even to attract some from the atmosphere, and this acid, *becoming chemically combined with the ammonia,* RENDERS IT MILD, and *ventilates it.* Lastly, the greater bulk of the liquid enables it to absorb a greater quantity of *sulphuretted hydrogen gas,* and on this account urine, diluted with water, contains more sulphuretted hydrogen than unmixed urine does.*

497. *Why should cattle urine not be left to putrefy for too long a period?*

Because, when it is kept for *three months,* or longer, in the tank, a considerable portion of the carbonate of ammonia formed in it is lost, for the *carbonate evaporates,* as well as the *caustic ammonia,* though more slowly. A small quantity of carbonate of ammonia is also continually evaporating from urine, even when mixed with water, and therefore when the caustic ammonia has been rendered mild by its conversion into carbonate, *no time should be lost in applying it as a manure to growing plants.*

498. The escape of the volatile ammonia is, however, *prevented most completely when the urine is mixed with humus* (mould), and then either left to putrefy, or laid on the field and immediately ploughed in. Urine five or six months old, contains *not a trace* of its original urea, mucus, and albumen; on the other hand, there are found in it *carbonate, sulphate,* and *humate of ammonia, humate of lime,* and

* Professor Spregnel.

"Nor thou disdain
To check the lawless riot of the trees,
To plant the grove, or turn the barren mould."—ARMSTRONG.

magnesia, common salt, and also some combined forms of *ammonia.* The acids belonging to the class of organic bodies, which still remain, *do not injure vegetation,* being *united to ammonia,* and therefore in some measure incorporated as inorganic manures.*

499. *Why, when a scum, with froth and bubbles, accumulate on the surface of putrefied urine, are they indications that the liquid is fit for use?*

Because these are *indications that the fermentation of the urine is completed,* and that it may NOW be applied without injury to growing vegetables; for the scum and bubbles are occasioned by the carbonic acid, which cannot even begin to escape until it has saturated all the ammonia present.

500. A scum is also formed on the surface of the urine at the *commencement* of the putrefaction, BUT THIS immediately ceases when the urea passes into decomposition; ammonia being thus produced, which will combine chemically with the carbonic acid.

501. In Belgium it is the practice, in order *to strengthen the manuring property of urine* mixed with water, to *add rape-cake* to the liquid, and *allow them to putrefy together in the tank.* The rape-cake contains many substances (of the nature of vegetable albumen) having *nitrogen* as one of their elements, which develope accordingly much *ammonia* on their decomposition; also a considerable quantity of *carbonic acid,* which immediately combines with the *ammonia* of the *urea,* as well as with that of the *rape-cake,* and renders it less volatile. This acid likewise *neutralizes the caustic qualities of the ammonia,* converting it into a beneficial manure.

502. *The addition of rape-cake to putrefying urine diluted with water* deserves, on account of these advantages, to be practised in other countries. Some indeed think that the water, because it becomes putrid, is a manure; but *this is not the case,* for it is NOT THE WATER that putrefies, but ONLY THE ORGANIC MATTERS held by it in

* Professor Spregnel.

"In ripening Summer the full laden vales
Give prospect of employment for the flails;
Each breath of wind the bearded groves makes bend
Which seems the fated sickle to portend."—THOMSON.

solution; the bulk, however, of the liquid serving the purpose, as we have seen, of *absorbing and retaining the gases developed during putrefaction*. Instead of the rape-cake, we might, indeed, add to the tank many *other vegetable substances* yielding much carbonic acid on decomposition, particularly such as are in a green state, as *weeds* from the garden and fields.*

503. *Why should undecomposed urine be applied to the soil in those cases where it is admissible?*

Because of the *loss of fertilizing power* which necessarily occurs in the course of fermentation, Although urine which froths and scums no longer contains *caustic ammonia*, and consequently is no longer injurious to vegetable life—*how much ammonia, up to the moment when this is the case, has escaped in the form of gas, and how much of the choicest manuring element has been, up to that point, lost by the urine?*

504. On this consideration, we should AT ONCE hasten to convey the urine *as fresh as possible* to the field: but *to a field which has* NO CROP ON IT. In fact, whoever is obliged, for want of straw, to collect the urine separately,—whoever, if he be compelled to do this, mixes no water with it, or who fails also to employ some neutralizing substance to combine with the ammonia which is produced in so great a degree during the summer, *suffers a loss of manure which exceeds all belief.*

505. It is, indeed, *only a gaseous substance*, and not a solid material *visible to the eye*, which thus escapes and is lost; but, for all that, *it is of greater importance to the nourishment of plants, than perhaps any other portion of the excrements.*

506. It is a common supposition that urine, in order to lose its caustic qualities, should putrefy in summer for five or six weeks, and in winter (provided the tank be well covered in) for eight or nine

* Professor Spregnel.

> "From their tenements,
> Pleased and refreshed, proceeds the caravan
> Through lively spreading cultures, pastures green,
> And yellow tillages in opening woods."—DYER.

weeks; but NO FIXED RULES CAN BE LAID DOWN on this point, as the quicker or slower rate of putrefaction depends upon the temperature of the air. The ripeness of the urine for manuring crops has arrived when it contains neither caustic ammonia, nor urea; a circumstance, however, which can only be ascertained with certainty by chemical investigation. If we add, for example, a small quantity of sulphuric acid to the urine, and there should arise, after a few moments, a gentle effervescence, we may assume that all the ammonia is saturated with carbonic acid: should, however, the effervescence ensue only after the addition of a further quantity of sulphuric acid, we may hence conclude that the urine still contains caustic ammonia. From the quantity of sulphuric acid required to effect this effervescence, or disengagement of carbonic acid, we may further draw an inference of the amount of ammonia still remaining in the urine uncombined with carbonic acid, as the sulphuric acid in the first instance saturates the free ammonia, before acting on that which is combined with carbonic acid. By means of a strip of blue litmus paper we may ascertain whether the whole of the carbonate of ammonia has been seized upon by the sulphuric acid; for when the paper is turned permanently red, the sulphuric acid has not only taken the whole of the ammonia into combination, but an excess of the acid is then present.*

507. *Why is urine more efficacious on light sandy soils than on clays and strong loams?*

508. Because the urine takes a longer period to penetrate clays, so that *much of its carbonate of ammonia*, which should be imparted to vegetation, *escapes as gas*. Urine has another advantage on light sandy soils, namely, its *binding them*, in some degree, *into a more consistent state;* while imperfectly decomposed dung, on the contrary, *only renders them still lighter.**

509. *Why is it unprofitable to lay urine on soils during a black frost?*

Because, when it becomes frozen before being absorbed

* Professor Spregnel.

"Shot up from broad rank blades that droop below,
The nodding wheat-ear forms a graceful bow,
With milky kernels starting full, weigh'd down,
Ere yet the sun hath tinged its head with brown."—BLOOMFIELD.

by the earth, *the greater part of the carbonate of ammonia escapes* in the course of a few days. Thus, the very essence of the manure is lost.

510. *When the ground is covered with snow*, on the contrary, it can be more easily applied; but it is always better to wait until the ground is again open; for the urine is rapidly absorbed by the soil, and the whole of the ammonia generally meets with so much humic acid that it becomes at once neutralized and fixed in the resulting humate of ammonia. If we would see the rapidity with which even the solid carbonate of ammonia volatilizes in winter, we have only to lay a weighed portion of it in the open air, and weigh it again a few days afterwards.*

511. *Why is a thin liquid manure generally best adapted to sandy soils?*

Because there are many such soils in which, *like magnesia, phosphoric acid* and *other minerals* occur, but, *in very small quantities.* If such soils are manured with *a too concentrated liquid* or other manure, there will not be a *sufficient quantity of mineral food* in the soil and the manure, to *counterbalance* the injurious effect which an *over-dose* of purely *nitrogenous food* is well known to produce. *Grass land*, under such circumstances, will produce produce abundant, but rank, innutritious, bad-keeping hay; *wheat* will give abundance of straw, but little and inferior corn; *Swedes*, *turnips*, and other root-crops, will make rapid progress, and then become attacked by disease.

512. We should therefore *dilute liquid manure largely*, if we wish to put it on *poor sandy soils.* Diluted with much water, it penetrates a larger mass of soil, and, so to speak, becomes more saturated with the mineral fertilizing matters that are wanted by the plant, and are so sparingly distributed throughout the soil. Liquid manure is particulary well adapted for porous sandy soils, because it penetrates them when properly diluted, deeply and uniformly, which is a great

* Professor Spregnel.

'The stable yields a stercoraceous heap,
Impregnated with quick fermenting salts,
And potent to resist the freezing blast."—COWPER.

advantage, since the porous nature of sand allows the roots of plants to penetrate the soil to a greater depth, in search of food. In other words, sandy soils are excellent vehicles for holding a diluted liquid manure, in which the different constituents occur in an immediately available, or *cooked* condition.*

513. *Why is water an essential constituent of the food of plants?*

One reason is, because plants derive their nourishment from the soil by means of *spongioles*, those soft, succulent extremities of the fibres which spread forth in every direction from the roots, and whose function it is to imbibe the food of the plant. This food consists of carbonic acid, ammonia, and various mineral matters, which must pass in a state of solution, by means of the spongioles, to the roots, and, rising thence to the stem, become converted, by a *digestive process*, into those substances which compose the structure of the plant. Water, therefore, is an indispensable constituent of plant-food, and no manure can enter the plant, until brought into a state of solution by this essential element.

514. The universal presence of water in manure is a fact that thrusts itself into notice in every dealing with the subject. Chemistry declares that it enters largely into the composition of even the solid forms of manure. Every ton of rich stable-dung contains 168 gallons of water; whilst even guano, dry as it is in appearance, contains from 12 to 17 per cent. of the same element of solution. By adding yet more water, until what was solid becomes liquid manure, we add no new constituent to the mass, but simply increase the proportion of one that it before contained.†

* Dr. Voelcker.

† R. Dymond "On Liquid Manure."—Bath and West of England Society's Agricultural Journal.

"Soon as the morning trembles o'er the sky,
And, unperceived, unfolds the spreading day;
Before the ripened field the Reapers stand,
In fair array."—THOMSON.

515. *Why are liquid manures better adapted than solid for fertilizing purposes?*

It is obvious that the more manure is *disintegrated* before it is committed to the soil, *the more evenly it will be diffused.* Without this disintegration, it will necessarily occur that one root, by its close neighbourhood to a lump of manure, will be surfeited, and perhaps poisoned, whilst another can find no source of nourishment within its reach.

516. That liquid manure is better adapted than solid for securing this desideratum, it needs no laboured argument to prove. The particles held in mechanical suspension are left in the soil by the simple process of mechanical filtration, whilst the water, which floated them to their destination, is evaporated or passed through the soil to a porous substratum, or is carried off through artificial drains. This separation of manure from the water is not only complete as regards the suspended particles, but as to the soluble portions also. Soils, and especially clay soils, operate chemically in wresting every portion of the manure from the water which had been its vehicle. The water, in passing through the soil, hands over to its keeping that portion of the manure which is absolutely dissolved, whilst, at the same time, it deposits, in a state of minute division, those other portions which it held in suspension, and which will also, by the process of decomposition, become, in due time, the food of plants.*

517. *Why does the water given to animals influence their excretions?*

Because water *differs materially in quality*, according to the sources from which it is derived: whether it is simply rain water, collected in tanks; or spring or river water, impregnated with mineral ingredients.

518. As a single ox drinks daily eighty and more pounds of water and there exists frequently in this quantity from half an ounce to an ounce of saline matters, consisting of *gypsum, common salt, phosphate*

* R. Dymond.

> "And all day long the winnowed chaff
> Floats round him on the sultry breeze,
> And shineth like a settling swarm
> Of golden-winged and belted bees."—STODDARD.

of lime (dissolved in carbonic acid), *carbonate of potash*, *carbonate of lime*, and *carbonate of magnesia*, it results, if we reckon a cow in the course of a year to furnish manure for about one English acre, that sixteen pounds per acre of these salts will be supplied by the water taken as drink, and, although it must be allowed that this is not much, *it deserves at the same time to be taken into account.*

519. It has been also maintained that the *state of health* of the animal may have a considerable influence on the goodness of the excrements, and that they will be so much the better the healthier the animal may be; no sufficient reason is, however, advanced for this assertion, for the stronger and healthier the animals are, the more do they *exhaust the food* given to them of those materials which are the best manures, as *nitrogen, sulphur, phosphorus, chlorine, &c.*

520. There does, indeed, exist a difference between the excrements of cattle in *summer* and *winter*: *when the summer* is *very hot* the process of digestion proceeds unfavourably, and as a natural consequence *the food is less exhausted*; on the other hand, *when the weather is cold*, the animals have a better digestion, and on that account abstract from the food more of its nourishment, or (what amounts to the same thing) more of its manuring elements.

521. It may always be regarded as an indication that the excrements of animals contain many powerfully manuring substances *when they pass quickly into the putrefactive state*, and develope a large quantity of the *offensive gases* and *ammonia*; for in such cases they contain, not only much *sulphur, phosphorus*, and *nitrogen*, but an abundance also of *chlorine, soda, potash, lime*, and *magnesia*; the whole of which, as we already know, are so much the more important in vegetation, as the soil manured with the excrements is *deficient in these particular substances.**

522. *Why, although fresh urine and solid excrements are in general hurtful when applied to growing crops, does fold-manuring prove beneficial?*

Because the urine of sheep contains *a larger proportion of water than that of cattle*; and also, even with the strongest

* Professor Spregnel.

"Hark! where the sweeping scythe now rips along,
Each sturdy Mower, emulous and strong,
Whose writhing form meridian heat defies,
Bends o'er his work, and every sinew tries."—BLOOMFIELD.

fold-manuring *the ground receives only a proportionately small quantity of droppings.* Thus, growing plants suffer no injury from the fresh manure in folding, for they are able to digest sufficiently the small quantity which they absorb.

523. It has been a practice of late years to sprinkle the droppings of the fold with *gypsum powder* before ploughing in, and, it is said, with good effect. It is possible that the gypsum undergoes decomposition by the carbonate of ammonia produced from the droppings, carbonate of lime and sulphate of ammonia being formed; and as the latter salt is more soluble in water than gypsum, it must, of course, come sooner into action. Gypsum requires 450 times its weight of water to dissolve it, while sulphate of ammonia is soluble in four or five times its weight. If this explanation, therefore, be correct, the operation cannot fail to be of use, especially in very dry seasons, when gypsum alone will not act.*

524. *Why is the urine of the horse less valuable than that of cattle as a manure?*

Because the nitrogen derived from the food is partly lost by *evaporation through the skin,* combined with *hydrogen;* the perspiration of the horse always having, from this cause, *an ammoniacal odour.* Horse urine is never worth the trouble of being collected and employed by itself, but is brought to the soil in mixture with solid excrement and litter.*

525. *Why is pig urine more caustic in its fresh state than that of cattle?*

Because it contains 1½ per cent. *more of urea,* out of which a *greater supply of ammonia* is created. Accordingly, before pig urine can be applied to plants, *it should have undergone putrefaction.* The ill effects of pig urine, not properly

* Professor Spregnel.

putrefied, are commonly ascribed to the presence of a *peculiar acidity;* but *they arise from no other cause than the caustic ammonia.*

526. It is asserted that *when the urine of the pig gets into a pond containing fish, it kills them.* Should this be actually the case, the effect would probably be occasioned by sulphuretted hydrogen, resulting from the decomposition of gypsum, or gaseous poison, to the action of which fishes are very sensitive, and of which a very small quantity kills them instantly.*

527. *Why has the ammoniacal liquor of gas-works been found to fail as a fertilizer, in certain cases?*

This liquor owes its chief fertilizing value to the *ammonia*, which exists in it *almost altogether as a carbonate*, and contains nothing detrimental to vegetable life; but, like *oxygen*, which is so essential for animal life, carbonate of ammonia must be CONSIDERABLY DILUTED, in order that it may produce a beneficial effect. In the instances where it has failed, *it has been applied in an undiluted form*, and being too powerful, has burnt up the vegetation it was designed to stimulate.†

528. *Why may gas tar be applied to lands undiluted?*

Because, though seemingly stronger than the ammoniacal liquor, it contains but little of the carbonate of ammonia, and for this reason may be applied undiluted, without danger of burning up the young plants.

529. As far as the tar itself is concerned, I am inclined to ascribe to it an injurious effect as a fertilizer; for it must *retard the decomposition of organic remains in the soil*, or in the *compost heap* to which it is added, and must thus delay the necessary preparation to which most organic refuse matters must be submitted before they can

* Professor Spregnel. † Dr. Voelcker.

"Before the ripened field the Reapers stand,
At once they stoop and swell the lusty sheaves;
Behind the master walks; builds up the shocks."—THOMSON.

be assimilated by the growing plants. If, notwithstanding, gas-tar produces a good effect, *it is only on account of the ammonia contained in ammoniacal liquor with which it is mechanically mixed.*

530. There cannot remain, however, a shadow of a doubt, that the ammoniacal liquor is a far more powerful, and at the same time economical manure, which will produce no injurious, and just as beneficial effects as gas-tar, *when properly diluted with water.* And, as ammoniacal liquor is cheaper than gas-tar, and as a fertilizer goes at least ten times as far as the tar, the utility of knowing on what principle the fertilizing effects of both refuse manures depend, will become at once apparent.*

531. *Why do decaying cabbage leaves emit a peculiarly offensive sulphureous odour?*

Because a part of the *sulphur* contained in the leaves unites with the *hydrogen*, either of *water*, or of the *decomposing vegetable texture*, and escapes as *sulphuretted hydrogen gas.*

532. Whoever has experienced the horrible smell of *sulphuretted hydrogen* given off by a large heap of fermenting *broccoli* or *cabbage-leaves*, will be ready to think that a very large part of the sulphur contained in the brassica tribe is unoxidized, and in the process of decomposition unites with hydrogen and becomes volatile, in preference to taking oxygen and remaining fixed. I have several times had an opportunity of testing this upon a neighbouring farm, where vegetables were largely grown. From twenty to thirty cart-loads of refuse broccoli leaves was no uncommon accumulation in the spring, and the odour given off would have convinced the most sceptical of the position here taken, without any attempt at chemical investigation. I once noticed the same phenomenon in an open field of broccoli belonging to the same farmer. The plants were planted about eighteen inches apart, and most of the lower leaves fell off and decayed where they fell. The smell was so offensive as to be a general subject of complaint, and several persons attempted to obtain a mitigation of the nuisance through the authorities.

* Dr. Voelcker.

> "Hour after hour, and day to day succeeds;
> Till every clod and deep-drawn furrow spreads
> To crumbling mould; a level surface clear,
> And strewed with corn to crown the rising year."—BLOOMFIELD.

533. *Putrefying nightsoil* is well known to give off a large part of its *sulphur* as *sulphuretted hydrogen*, and *hydrosulphate of ammonia*, and that the same thing occurs to every manure-heap may be proved by any one who will take the pains to collect and condense the fumes which arise, and to analyse the product so obtained. I believe that *all the unoxidized sulphur takes hydrogen in preference to oxygen in a manure heap*, but am far from supposing that the loss of sulphur from the formation and volatilization of sulphuretted hydrogen is limited to that; for I believe that *sulphates* are constantly decomposed by the agency of hydrogen, which combines with their oxygen to form water, and then with their sulphur as sulphuretted hydrogen. That this is quite possible, any farmer may easily satisfy himself.*

534. *Why is the practical chemist able to determine the component parts of plants, soils, or manures, and to declare their properties and value?*

Because, by extensive chemical knowledge of elementary and compound substances, and the manner in which they are affected by water, and other solvents, he is able to separate the component parts of soils, and ascertain their peculiar properties. In doing so, he takes care *to draw forth the several components* AS THEY NATURALLY EXIST IN THE SOIL, *and* NOT *to produce* OTHER COMPOUNDS *from them by disturbing their original arrangements.*

535. Take an example of a very simple process of analysis, which may indicate in some degree how the chemist proceeds in matters of greater difficulty: *Mix common salt and sand.* It would be almost impossible to separate them perfectly by *picking out their individual grains*, even if aided by a fine forceps, and a powerful magnifier; therefore, as such *mechanical means* fail in effecting the desired analysis, *chemical means* must be tried.

536. Experience teaches that *water will dissolve salt*, and that it *will* NOT *dissolve* sand: this simple fact affords a clue to the method of effecting their separation. *Agitate* the mixture with *water*, then allow

* Rev. W. R. Bowditch.

"And mirth and music cheer the toil;
While sheaves that stud the russet soil,
And sickles gleaming in the sun
Tell jocund harvest is begun."—PRINGLE.

it to *rest*; the *sand* will rapidly *sink to the bottom of the glass*, and *leave the water perfectly clear*, yet *containing nearly the whole of the salt in solution*. Decant this *from the sand*, into a *shallow basin*, place it in a *warm oven*, *that the chemical agency of heat may* DRY AWAY THE WATER, *and then the* SOLID SALT will remain.

537. Take another example: Mix equal heaps of *salt*, *sand* and *sawdust*. Suppose them to represent *three distinct components of a* SOIL, and that their *separation* will be required. *Agitate with water*, as before, then allow it to *rest*: the *sand* will *sink*, the *salt* will *dissolve*, and the *sawdust* will *float*: then decant the solution *into a fine sieve*; the *sawdust* will be *caught by the sieve*; the *sand* will *remain in the vessel* from which the solution is decanted; and the solution of salt may then be *evaporated to dryness*.*

538. *Why, in submitting soils to analysis, should due regard be paid to the geological characteristics of the lands from which the samples are taken?*

Because the earth frequently contains a number of veins or strata in the same formation; and *many of these strata often crop out, or come to the surface of the earth in the space of a hundred yards*; also, each of these strata is *composed of very different matter*, as respects *colour* as well as *substance*; therefore, soil taken from either of those strata and analysed, cannot give the contents of any one of the others.

539. It is true, that on arable land, the different strata become *mixed in a degree* by the action of the *plough* and *harrow*, but not enough to make the soil of the whole field alike. I have observed, in the spring of the year, in dry weather, that *scarcely any piece of arable land is of the same colour all over*; some of several different shades in the space of eight or ten acres; and I have come to the conclusion that the difference in colour is caused by the different strata coming up to the surface. * * * I apprehend it will be necessary, before chemistry can decide the relative fertility or barrenness of a whole farm, or parish, or district of country, or even a single

* Professor Griffith's "Chemistry of the Four Seasons."

"The harvest treasures all
Now gathered in beyond the rage of storms
Sure to the swain; the circling fence shut up,
And instant Winter's utmost rage defied."—THOMSON.

district, or field, to examine every stratum that crops out in such a field, and the subsoil immediately under it; also its colour, consistency, and the vegetation thereon.*

540. *What are the main points of agricultural chemistry upon which conflicting opinions have been formed?*

They are those represented by the discussion between Baron Liebig and Mr. Lawes. In the year 1840, Baron Liebig first published in England his great work on agricultural chemistry. In that work the leading principle advanced was, that *in order permanently to maintain the fertility of cultivated land, it was necessary to restore to it* ALL *the substances contained in the various crops exported from the farm.*

541. But however perfect the theory in the case of normal vegetation, such as that of our natural woods and plains, or when applied to the reclamation of a virgin gravel-pit, it was soon found that the teaching of Baron Liebig's work, though invaluable in its *suggestive* capacity, was yet not sufficiently matured to be of use to the practical agriculturist; and the entire failure of the numerous special or UNIVERSAL manures which appeared in rapid succession, not even excepting the one which received the sanction of the great philosopher himself, plainly proved that his various conclusions required important modifications before they could be made applicable to the artificial wants of improved agriculture. These modifications have been supplied by Baron Liebig from time to time in his later works, after personally inspecting the existing condition of practical agriculture in Great Britain. Suggestions of a totally opposite kind have been advocated by Mr. Lawes; and it is on the comparative merits of these respective adjustments that British agriculturists are now called on to decide.†

542. About the time of the appearance of Baron Liebig's first work, Mr. J. B. Lawes, F.R.S., F.C.S., of Rothamsted, Herts, assisted by Dr. J. H. Gilbert, were conducting a

* J. Arkell, "On the Indications of Fertility or Barrenness of Soils."—Journal of the Royal Agricultural Society. † Ibid., Vol. XII.

"Unassisted through each toilsome day,
With smiling brow the ploughman cleaves his way,
Draws his fresh parallels, and, widening still,
Treads slow the heavy dale, or climbs the hill."—BLOOMFIELD.

course of scientific experiments, on the application of special manures to various crops. In the mean time, in later editions of Baron Liebig's works, and in other publications, Baron Liebig treated the MINERAL ingredients of manure as of paramount importance, and intimated that, if these latter were present in sufficient quantity. and in available form, the requisite nitrogen and carbon would be obtained solely from atmospheric sources. The practical deduction to be drawn from these opinions is, that *the first step to be taken to improve the fertility of land is to employ a manure containing an ample supply of the* MINERAL *constituents of the crops to be grown.* Professor Liebig's words were :—"*The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure.*"

543. In opposition to this, Mr. Lawes' experiments convinced him that, in the ordinary cultivation of land, *the* NITROGEN, *and* NOT THE MINERALS, *would generally be found deficient, and that the first step towards improvement must therefore be, to employ a highly nitrogenous manure, especially where the growth of corn was the principal object.**

544. Hence it appears that the point in dispute, INVOLVES A FUNDAMENTAL DIFFERENCE, as it would, when carried out in practice, cause an improving farmer to lay out his money in the purchase of manures of totally different characters and effects, accordingly as he adopted the views of one or other of the opposing sentiments. The facts and arguments contained in the accounts of Mr. Lawes' experiments, were considered so conclusive by practical agriculturists, that for some years past his recommendations have

* For an elaborate statement of these experiments, and their results, see the Journal of the Royal Agricultural Society, Vol. XII. For Baron Liebig's Reply, see his "Principles of Agricultural Chemistry, with Special References to the late Researches made in England." And for Mr. Lawes' Rejoinder, and a further series of Experiments, see the "Royal Agricultural Society's Journal," Vol. XVI.

"From morn till night, in autumn time,
When yellow harvests load the plains,
Up drive the farmers to the mill,
And back, anon, with loaded wains."—STODDARD.

been very generally acted upon, and such excellent results obtained as to produce a deep conviction of the soundness of the views on which they were founded. In fact, *the scientific creed of the British farmer of the present day might almost be said to begin and end with the two axioms that* NITROGEN *is the principal desideratum in a manure for* CORN, *and* PHOSPHORUS, *in a manure for* TURNIPS.*

545. *What are the practical deductions from scientific theories of agriculture, as at present accepted?*

Many important problems remain yet to be solved; and a wide field remains open for observation and experiment. In the present state of agricultural knowledge in connection with chemistry and geology, it may be assumed :—

546.—1. That SUBSTANCES RICH IN NITROGEN increase the verdure, lengthen the straw, and generally promote and prolong the growth of plants.

547.—2. That LIME, in its more common forms, generally shortens the period of growth, strengthens the stem, and hastens the time of ripening, both of corn and root crops.

548.—3. That certain SALINE SUBSTANCES, applied alone, and even in comparatively minute quantity, produce a remarkable—what may almost be called a marvellous—effect upon certain crops on certain soils.

549.—4. But CHANGE THE CROP OR THE SOIL, or the SEASON, or apply them in the same circumstances A SECOND or A THIRD TIME, and frequently NO SENSIBLE EFFECT will follow. [This is very ably explained by Liebig's theory stated hereafter.]

550.—5. That where ONE SUBSTANCE APPLIED ALONE refuses to produce a visible effect, a MIXTURE OF TWO or more may give rise to striking differences.

551.—6. That PHOSPHORIC ACID, LIME, and certain forms of organic matter are essential constituents of such a mixture as shall everywhere, and in all circumstances, produce a marked and beneficial effect on old cultivated land, to which no other manure is applied.

* Journal of the Royal Agricultural Society, Vol. XVI.

"Then say, ye swains, whom wealth and fame inspire,
Might not the plough, that rolls on rapid wheels,
Save no small labour to the hoe-armed gang?"—GRAINGER.

552. Such general deductions as these are important bases for future practical researches, and, perhaps, to have attained a degree of certainty in regard to them alone is worth all the expenditure the experiments have cost. We have, indeed, other more special conclusions which may be regarded as *probable;* for instance:—

553.—1. That the so-called soluble saline substances—the *salts of potash, soda, magnesia,* &c., are grateful to our ROOT CROPS, in which they largely exist.

554.—2. That those which contain *sulphuric acid,* have a specially beneficial action upon *leguminous plants.*

555.—3. That the use of *common salt* adds *weight to the grain.*

556.—4. That on *mossy land* the use of *bones* tends to *fill the ear.*

557.—5. That *lime* and *salt* are *better than lime alone* on some soils, in *giving strength to the straw.*

558.—6. That mineral manures, *applied alone,* act *like lime* in *shortening the period of growth.*

559. Such *probable* deductions are not without an actual money value as guides to the practical man; but they are almost beyond price to an advancing science, as they point the way to new experimental researches, by which the domain of ascertained truth will be enlarged.*

560. *What are the views of Liebig, expressed in his latest work, after reviewing the discussions and experience of the past sixteen years?*

They are set forth in his new work,† and are expressed in the following brief epitome:—

561. We have hitherto believed that plants received their food *from*

* Professor Johnston, "On the Present State of Agriculture in its Relations to Chemistry and Geology;" Royal Agricultural Society's Journal, Vol. IX.

† Letters on Modern Agriculture, by Baron Von Liebig. Edited by John Blyth, M.D., Professor of Chemistry, Queen's College, Cork. London: Walton Maberly, 1859.

" She learned the churlish axe and twybill to prepare,
To steel the coulter's edge, and sharp the furrowing share."—DRAYTON.

a SOLUTION, and that the rapidity of its effect was in direct proportion to its solubility.

562. *But this has been a great mistake.* We have inferred from the effect of water and carbonic acid on rocks, a similarity of action on soils; *but this conclusion is false.*

563. By the simplest experiment, any one may satisfy himself that *rain water filtered through field or garden soil* does NOT *dissolve out a trace of potash, silicic acid, ammonia,* or *phosphoric* acid. The soil does NOT *give up to the water one particle of the food of plants which it contains.* [It must be borne in mind, however, that in this "simple experiment," *no vital action takes part.* The agencies are simply *mechanical* and *chemical:* can the result of an experiment in which these alone engage, satisfactorily determine what may occur, when life takes part in the operation?] On the other hand, if rain and other water, holding in solution *ammonia, potash, phosphoric* and *silicic* acids, be *brought into contact with the soil,* these substances *disappear almost immediately from the solution;* the soil withdraws them from the water. *Only such substances are withdrawn from the water by the soil as are* INDISPENSABLE ARTICLES OF FOOD FOR PLANTS; all others *remain wholly or in part in solution.*

564. From the action just described of soil on potash, ammonia, and phosphoric acid, there can be no doubt that *the majority of our cultivated plants cannot receive out of a solution from the soil their essential mineral constituents.*

565. It is more than probable that it is assigned to the majority of our cultivated plants to *receive their nourishment directly from those portions of the soil which are in immediate contact with their rootlets,* and that they *die* when their food is presented to them in *solution.* The action of *concentrated* manures, which are said by agriculturists to *burn* the young plants, appears to stand in some connection with this supposition.

566. From the action of soils just described, it follows *that plants must themselves play some peculiar part in the absorption of their food.*

567. *With the chemical property of soils there* is associated a

> "'Tis sweet to meet the morning breeze,
> Or list the gurgling of the brook;
> Or, stretch'd beneath the shade of trees,
> Peruse and pause on Nature's book."—CLARE.

physical quality, not less remarkable: the power which they possess of *attracting moisture from the air, and condensing it in their pores.* A second source from which the dry soil derives moisture by absorption is presented by the *deeper-lying moist strata.* From these a constant distillation of water is taking place towards the surface, accompanied by a corresponding *evolution of heat.* This vapour supplies the wants of plants, and at the same time raises the temperature of the ground.

568. This is one of the most remarkable natural laws: THE OUTERMOST CRUST OF THE EARTH IS DESTINED FOR THE DEVELOPMENT OF ORGANIC LIFE, AND ITS BROKEN PARTICLES ARE ENDOWED WITH THE POWER OF COLLECTING AND RETAINING ALL THE ELEMENTS OF FOOD WHICH ARE ESSENTIAL FOR THE PURPOSE.

569. *We have now obtained more exact information on the part played by humus* in vegetation, and can predict in what cases its presence will be beneficial or hurtful. We know that it is useful *only* when the soil contains in sufficient quantity the *fixed mineral constituents* serviceable to plants. BY ITS DECOMPOSITION IN THE SOIL, HUMUS FORMS A SOURCE OF CARBONIC ACID, BY WHICH THE FIXED ELEMENTS OF FOOD ARE RENDERED SOLUBLE, AND CAPABLE OF BEING DISTRIBUTED IN ALL DIRECTIONS.

570. *We know of no other way* in which the *earthy phosphates* are dispersed through the soil, than by means of *carbonic acid water.* If it is true that one of the chief effects of humus, on the decaying remains of plants in soils or in manures, consists in its forming a *source of carbonic acid,* with which the air and water in the ground are enriched; if it is also true that *this* carbonic acid water renders the earthy phosphates *soluble,* then there can be no doubt that the SALTS OF AMMONIA, which possess the same solvent property, can in this respect *replace the organic matters,* and thus exert an equally favourable influence on the growth of plants.

571. As our cultivated plants undoubtedly *absorb through the leaves* as much nitrogenized food in the form of ammonia, and nitric acid *from the air,* as well as *dissolved in rain and dew,* as uncultivated plants, which receive no nitrogenized manure from the hands of man; we can therefore conceive that *the agriculturist will seldom have to seek the reason of his poor crops in a deficiency of ammonia or*

"Its dark green hue, its sicklier tints all fall,
And ripening Harvest rustles in the gale;
A glorious sight if glory dwells below,
Where Heaven's munificence makes all the show."—BLOOMFIELD.

nitrogenized food ALONE, and that he must first of all direct his attention to CERTAIN OTHER conditions, in order to improve his harvest.

572. The proximate cause of the powerful action of guano must be sought for in THOSE MATTERS WHICH IN IT ACCOMPANY THE AMMONIA.

573. In every case the *produce* of a field, and the *duration* of its fertility, bear a fixed relation to the sum of the *mineral* substances in the soil. The abundance of the crop is *proportional to the rapidity of the action of the mineral matters* IN A GIVEN TIME, By the use of tillage, the TOTAL produce of a field over *a given time* is not *increased*, but only the *quantity* obtained in a *given time*. If a field can yield in 100 years exactly 100 remunerative wheat crops, it may, by mechanical and chemical means, be made to yield in 50 years *as much as it would have done in the* 100 *without these means*, and in *half the time*, IT WOULD BE EXHAUSTED IN THE CULTIVATION OF WHEAT.*

574. *If one plant possesses twice the extent of surface of leaves* which exists in another, it will, during the same period of vegetation, *extract double the quantity of nitrogen from the air.*

575. By manuring his fields with nitrogenous substances, the agriculturist exercises an *immediate influence* on the produce; and the effect of these manures, through the nitrogen they contain, is *in inverse proportion to the absorbing leaf and root surface, and to the length of the time the crop requires to vegetate.*

576. *Ammonia is necessary as food to all plants;* but a supply of it in MANURE is, in the agricultural sense, *not useful to all cultivated plants.* As a rule, the agriculturist does not *manure his clover* field

* The deduction is that agriculture, as at present pursued, tends to a present quickening and increase of produce *at the cost of the future exhaustion of soils.* Thus Liebig says:—"The prevailing system of agriculture for half a century has been one of spoliation; and that, if persisted in, the inevitable result will be, at no distant date, the ruin of the fields of agriculturists, and the impoverishment of their children and posterity." Again: "The apparently remunerative employment of these means on many fields may last for a long time, ere the agriculturist becomes aware of the injury he is doing himself by neglecting to return the *mineral substances* removed by his crops; *but the longer he continues by them to obtain large crops, he is approaching nearer and nearer the limits at which they must cease.*"

"Howe'er reluctant, let the hoe uproot
The infected cane piece; and with eager flames,
The hostile myriads then to embers turn."—GRAINGER.

with *nitrogenous matter*, because the crop of clover is generally not thereby visibly increased, or only very slightly; whilst he reaps a decided advantage in the increase of his produce by applying these matters to his *corn fields*. The agriculturist, therefore, *makes use of green crops as a means of increasing the productiveness of corn crops.*

577. *Green crops which thrive without nitrogenous manures,* collect from the *soil* and condense from the *atmosphere*, in the form of blood and flesh constituents, the *ammonia* supplied from these sources. When the agriculturist feeds his cattle, sheep, and horses, with these green crops, *he obtains in their solid and liquid excrements the nitrogen of the fodder in the form of ammonia*, and highly nitrogenized products, and thereby a supply of manure for his corn fields.

578. The agriculturist furnishes to certain plants, having a scanty supply of leaves and roots and a short existence, in *quantity* as manure, the nitrogen which they have not *time* to absorb *from natural sources.*

579. *The roots of plants extract their food from those portions of the soil*, penetrated with water, which are in *direct contact with their absorbent surfaces*, and such portions of soil must contain the *whole quantity* necessary for the complete development of the plant, since the roots can receive none of them, *except from the particles of earth with which they are directly in contact.*

580. *The exhaustion of a soil* inevitably happens, even when there has been withdrawn from the soil by a course of crops *only* ONE *of all* the different mineral substances necessary for the nourishment of plants; *for the one which is wanting, or exists only in deficient quantity, renders all the others inefficient, or deprives them of their activity.*

581. *The quantity of food which a plant obtains* from one and the same soil is *in proportion to its absorbent root surface.* Of two species of plants, which require the same quantity, and a similar relation of mineral food, the one with *double extent of root surface* takes up *double the quantity of food.**

* Thus it is manifested that root spreading plants are *soil-feeders*; that leaf-spreading plants are *air-feeders*; that is, they chiefly feed upon the air and soil respectively.

"Hail, rural views! life's pure unmingled sweets;
Long-winding walks, and ever-calm retreats!
Where still succeeding charms of various kind
Infuse a balmy temperance of mind."—B

582. *A field is not exhausted* for corn, clover, tobacco, and turnips, *so long* as it still yields remunerative crops *without requiring restoration of the minerals which are removed.* It is *exhausted* at the moment *when the hand of man is needed to restore to it the failing conditions of its fertility. The great majority of our cultivated fields are, in this sense, exhausted.*

583. *The presence of decaying organic matter in a soil* DOES NOT *in the slightest degree retard or arrest its exhaustion by cultivation;* it is therefore impossible that an increase of these substances *can restore the lost capacity for production.**

584. *The incombustible elements of cultivated plants* do NOT of *themselves return to the soil like the combustible,* or the atmosphere from which they are derived. By THE HAND OF MAN ALONE are these essentials of the life of plants *given back to the soil.* By FARM-YARD MANURE, in which *these conditions are fulfilled,* the agriculturist, as if by a law of nature, *restores to his field its lost powers of production.*

585. *Farm-yard manure restores thoroughly the power of producing the same series of crops, a second, third, or a hundred times. It arrests fully, according to the quantity employed, the state of exhaustion; its application may render a field more fertile, in many cases more so than ever it has been. The action of farm-yard manure depends most undoubtedly on the amount of the incombustible ash-constituents of plants in it, and is determined by these. Dung, in itself, has an agricultural value* ONLY *in so far as it contains the conditions necessary for the growth of the saleable produce; the mere size or extent of a dung-heap does not constitute its richness.*

586. *Were it possible* for a plant to grow, flower, and bear seed *without the co-operation of mineral matters,* it would be UTTERLY USELESS TO MAN AND ANIMALS. A dog will die of hunger in

* The meaning is, that restoring *organic matters* ALONE to the soil, will not prevent its becoming *exhausted* of *mineral constituents,* necessary to vegetable life. The addition of organic manure may *stimulate the growth* of a heavy crop of a particular plant on a given soil; but the *next* crop, of the *same plant,* upon the *same soil,* MAY FAIL, *though treated with the like manures,* BECAUSE *the restoration of the* mineral *elements of the plants to the soil, has not been attended to.*

> "Oft did the harvest to their sickle yield;
> Their furrow oft the stubborn glebe has broke;
> How jocund did they drive their team afield;
> How bowed the woods beneath their sturdy stroke!"—GRAY.

presence of a dishful of raw or boiled white and yolk of eggs, in which is wanting *one* of the substances most important for the formation of blood. The first trial teaches him that *such food* is as inefficient as a *stone* for purposes of nutrition.

587. Liebig thus indicates the opinions of those who oppose his views:—Teachers of practical agriculture, universally recognised to be the most distinguished and skilful, have for sixteen years, and up to a recent period, endeavoured to prove that these laws have no value in connection with *fertile* soils; that the *increase of the fertility of a field by fallow and by mechanical operations, and the removal of the mineral matters of the soil in the crops, do not diminish the duration of this fertility; that the ground may retain continuously its fertility, even when its cultivators neglect to supply the minerals which have been withdrawn*, that is, *to restore the original composition of the soil.* They teach that a *fertile* field contains an INEXHAUSTIBLE amount of the *ash-constituents* of plants, and that consequently, deficiency of these can NEVER occur in it; that the fertility of a soil is in exact proportion to the quantity of *combustible matters*, of *humus*, and *nitrogen* in it; and that the *want of fertility* is owing to the want of *nitrogen*, and the exhaustion of the land depends on the withdrawal of the latter. Manure, they assert, does not produce its beneficial effects by returning to the ground those elements which have been withdrawn from it in corn, clover, turnips, tobacco, flax, hemp, madder, wine, &c., but it is in proportion to the amount of *nitrogen* it contains. Its incombustible elements only quietly look on.

588. The view held by Liebig is this, in brief: THAT ORGANIC MATTERS COME NATURALLY TO THE PLANT, IN ABUNDANCE, AND THAT THE CARE OF MAN IS REQUIRED TO RESTORE THE MINERAL CONSTITUENTS WHICH PLANTS TAKE UP FROM THE SOIL.

589. The view of those who oppose that opinion is: THAT THE MINERAL constituents of plants exist abundantly in fertile soils, and that man is required TO SUPPLY ORGANIC SUBSTANCES THAT THE PLANT MAY BE STIMULATED TO ACT UPON THE SOIL.

590. It is a matter of great importance and interest that the minds of scientific and practical men are now

"In those low paths which poverty surrounds,
The rough rude ploughman, on his fallow-grounds,
Will often stoop inquisitive to trace
The opening beauties of a daisy's face."—CLARE.

directed to these questions. We have already given the crude theory of agriculture which prevailed in the seventeenth century, and which was followed by a "new theory" towards the commencement of the eighteenth century, which ran as follows:—

591. "Although the spirit of mercury be that active and moving part that principally appears in the generation or conception of any vegetable or animal, and is also the first that flies in the separation or dissolution of bodies; yet it is imbecile and defective without that most excellent, rich, and *sulphureous principle*, which is of a little thicker consistence than the *spirit*, and next unto it the most active; for when any mixture or compound is separated, the spirits first fly, then follow after the *sulphureous particles*, the temperature of everything so far as to the heat, consistence, and curious texture thereof doth principally depend on *sulphur*, from hence every plant, fruit, and flower received those infinite varieties of forms, colours, gusts, odours, signatures, and vertues; it is that which is the proper *medium* to unite the more volatile *mercury* or *spirit* to the more fixed *salt*. This *sulphur* or oyly part, is easily separated and distinguish'd in *vegetables* by the more curious; it ariseth out of the earth with the aforesaid *mercury* or *aqueous spirit*, though not at the first discernable, yet in every plant more and more matured and augmented by the sun's influence, as the *seed* or *matrix* is more or less inclined to this principle. This is also that which gives to our hot and stinking dungs, soils, or manures, the oleaginous pinguidity and fertility, and which begets that fiery heat which is in vegetables, hay, corn, &c., laid on heaps not thoroughly dry." *

592. The most unscientific reader will at once discover the great advances that have been made, and be encouraged to place reliance in the investigations which are now being eagerly pursued.

* Philp's History of Progress in Great Britain, Art.: "Progress of Agriculture."

"Nor does the faithful voice
Of Nature cease to prompt their eager steps
Aright; nor is the care of Heaven withheld
From granting to the task proportioned aid."—AKENSIDE.

II.

METEOROLOGICAL INFLUENCES AFFECTING VEGETATION LIGHT, HEAT, ELECTRICITY; CLOUDS, RAIN, DEW, FROST HAIL, SNOW; WINDS, ETC.

593. In the earliest ages, as far back as history enables us to trace the operation of the human intellect, we find mankind interested about meteorological phenomena. A circumstance by no means astonishing, *when we consider the vast importance of this science to the shepherd and the agriculturist,* and the interest the study of it affords, as a means of enabling men, by anticipating the event of terrible atmospheric commotions, to provide in some measure against their effects. The beauty, also, of many atmospheric phenomena, and the interesting variety of scenery which they produce for the spectator; together with the natural curiosity excited about their causes, which man is organized to feel, have contributed in a great measure to interest people in this science.*

594. As an instance of the degree of skill that may be attained in meteorological observations, without absolute scientific knowledge, we may quote Saussure's remark, that it is humiliating to those who have been much occupied in cultivating the science of meteorology, to see an agriculturist or a waterman, who has neither instruments nor theory, foretell the future changes of the weather many days before they happen, with a precision which the philosopher, aided by all the resources of science, would be unable to attain.†

595. *What are the effects of light upon vegetation?*

That which is familiarly named *light,* has been found to consist of *three* elements or properties: 1st, *luminosity,* or that which is commonly called *light;* 2nd, *heat,* or that which is frequently termed the "*warmth of sunshine;*" 3rd, a *chemical property,* manifested only from its *effects,* to which the name of *actinism* has been given.

596. Without *light* it is well known that no plant can thrive; and if it do grow at all in the dark, it is always white, and is, in all other

* Forster "On Atmospheric Phenomena." † *Essais sur l'Hygrométrie.*

"The village pours
Her useful sons abroad to various toil:
The labourer here, with every instrument
Of future plenty armed."—MALLET.

respects, in a weak and sickly state. Healthy plants are, probably, in a state similar to *sleep* in the absence of light, and do not resume their proper functions but by the influence of light, and especially the action of the rays of the sun.*

597. *How necessary light is to the health of plants*, may be inferred from the eagerness with which they appear to long for it. How intensely does the *sun-flower* watch the daily course of the sun! How do the countless blossoms nightly *droop when he retires*, and the blanched plant strive to reach an open chink through which his light may reach it! Thus *a potatoe has been observed to grow up in quest of light from the bottom of a well ten feet deep; and in a dark cellar a shoot of twenty feet in length has been met with, the extremity of which had reached and rested at an open window.*†

598. *What is the immediate effect upon vegetation of the* luminous *rays of the sun?*

The *luminous rays excite and quicken the vital action of growing plants* by which *they decompose carbonic acid gas*, and extend their growth by assimilating *carbon* with their systems in the form of woody fibre, and other parts of their solid structures.

599. The conclusions I am compelled to draw are—that the luminous principle of the sun's rays is essential *to enable plants to effect the decomposition of the carbonic acid of the atmosphere, and form their woody structure;* that some plants require more light than others to effect this decomposition; as, for instance, we find the *sage* and *ten-week stocks* decomposing carbonic acid with much *less light* than the *cabbage* or the *mint*. We may also infer from numerous observations that the decomposition of carbonic acid by plants is not a simple chemical operation, but *the result of the vital principle of the growing plant*, which *requires* the external stimulus of light to call it into action.‡

600. The influence of *light* upon vegetable substances is demonstrated

* Dr. Priestley. † J. Browne.
‡ Professor Hunt's "Researches on Light."

"What once were kernels from his hopper sown,
Now browning wheat-ears and oat-bunches grown;
And pea-pods swelled, by blossoms long forsook,
And nearly ready for the scythe and hook."—CLARE.

by the following facts, which are a few only out of a large number that might be cited. Remarkable changes take place in the colours of many *vegetable powders*, such as the powdered leaves of the *fox-glove*, the *hemlock*, the *henbane*, the *aconite*, &c., which are used for chemical and medical purposes. It is found that these powders do not merely lose *colour*, passing from a green into a slaty gray, and, ultimately, into a dirty yellow; but they undergo some *decomposition*, by which, at the same time, they lose much of their *medicinal activity*, and, after a time, lose their properties. The powders of *Cascarilla bark*, of the *valerian root*, and some others, are found to adhere with considerable firmness to the sides of the bottles turned to the *light*, whereas the sides in *shadow* are kept clear.*

601. During the hours of darkness, the *flat-leaved calcalia* (native of the Cape of Good Hope), assimilates large quantities of *oxygen*, and in the morning is as *sour* to the taste as *sorrel*. By the influence of the morning light it *loses this oxygen*, and at noon it is *tasteless*, and, by the continued action of light, still more is abstracted, and the plant is positively *bitter* in the evening.*

602. The leaves of plants placed in a cellar became *green* on exposure to a *strong light from lamps*, and their *flowers* even *reversed their natural periods of opening*, when the cellar was *illuminated by night*, and kept *dark by day*.†

603. *What are the effects of solar* heat?

Heat influences vegetation from the *shooting of the germ*, to *the perfection of the fruit*; but its *maximum influence* appears to be exerted at the time when the *flower* is developed, and the *seed perfected*.

604. At this season the effect of solar heat is to facilitate the assimilation of *oxygen* by the *flowers* and *fruit*. It has been shown by Priestley, Scheele, &c., that flowers *consume much more oxygen* than any other part of the growing plant. Saussure has shown that *flowers will not be developed without*

* Professor Hunt. † De Candolle.

"The sharpened share shall vex the soil no more,
But earth unbidden shall produce her store;
The Land shall laugh, the circling Ocean smile,
And Heaven's indulgence bless the holy isle."—DRYDEN.

oxygen; that, so far from *giving out oxygen* when exposed to sunshine in larger quantities, *as leaves do,* they *consume even more oxygen than before.*

605. Here we find the process which has brought the plant to this stage of growth, is reversed, and *in place of the decomposition which is effected by light and actinism,* we have a process of *re-oxidation,* under the influence of *heat,* which *facilitates the flowering of plants,* and the *perfecting of their reproductive principles.*

606. *What is the effect of* actinism?

Actinism, or the *chemical* property of light, *quickens germination.* Seeds *do not germinate well in light,* but when buried in the earth, they are reached and influenced by the *chemical rays,* while the *luminous* ones are cut off. When, however, the germ has put forth its root-leaves, these rise above the surface, and then *the luminous rays stimulate those vital functions upon which the growth of the plant depends.*

607. The most casual observer could not fail to remark the peculiar influences of the solar agencies, at different seasons of the year. In *spring* a fresh and lively green pervades the field and forest, and *at this season I find the actinic principle the most active, and, as compared with light and heat, in very considerable excess.*

608. In the *summer,* vegetation assumes a darker hue, and, as the season advances, *the quantity of light and heat increases relatively to the actinic principle, in a very great degree.*

609. The *autumn* foliage assumes a russet brown, and *at this season light and actinism both diminish, and the heat rays are, relatively to them, by far the most extensive.*

610. The influence of *actinism* in the germination of seeds, has been demonstrated by some very conclusive experiments. In Professor Hunt's work "On the Physical Phenomena of Nature," he explains that if seedr are placed under all the necessary conditions of warmth

"Fair morn ascends: soft zephyr's wing
O'er hill and vale renews the spring;
Where, sown profusely, herb and flower,
Of balmy smell, of healing power."—MALLET.

and moisture, but *exposed to a strong light, they will not germinate;* but if we obstruct the luminous rays, allowing the chemical power to act, which may be done by the interposition of blue glass, the birth of the young plant proceeds without any interruption. The seed is buried in the soil, when the genial showers of spring, and the increasing temperature of the earth, furnish the required conditions for this chemistry of life, and the plant eventually springs into sunshine. If, however, we place above the soil a yellow glass, which possesses the property of *separating light from actinism* or chemical power, and thus consequently ensure the operation only of *light* and *heat* upon the soil, NO SEEDS WILL GERMINATE. If, on the contrary, a blue medium is employed *by which actinic power, freed from the interference of light, is rendered more active,* germination takes place more readily than usual. Thus we obtain evidence that even through some depth of soil this peculiar solar power is efficient, and that under its influence the first spring of life in the germ is effected.*

611. Some time subsequently to the publication of this theory, the following letter was addressed to Professor Hunt, by Mr. Charles Lawson, of Edinburgh, a gentleman largely connected with the seed trade:—

"*Edinburgh,* 1, *George the Fourth's Bridge,*
"*Sept.* 8, 1853.

"MY DEAR SIR,—I am favoured with yours of the 5th, relative to my practical experience in the effect of the chemical agency of coloured media on the germination of seeds, and the growth of plants.

"I must first explain that it is our practice to *test the germinating powers of seeds* which come to our warehouses before we send them out for sale; and, of course, it is an object to discover, with as little delay as possible, the extent to which the vital principle is active, as the value comes to be depreciated, in the ratio in which it is dormant. For instance, if we sow 100 seeds of any sort, and the whole germinate, the seed will be of the highest current value; but if only 90 germinate, its value is 10 per cent. less; if 80, then its value falls 20 per cent.

"I merely give this detail to show the practical value of this test, and the influence it exerts on the fluctuation of prices.

"Our usual plan formerly was to sow the seeds to be tested in a

* Professor Huut.

> "The freshen'd landscapes round his routs unfurled,
> The fine-tinged clouds above, the woods below,
> Each met his eye—a new-revealing world,
> Delighting more, as more he learned to know."—CLARE.

hotbed or frame, and then watch the progress, and note the results. It was usually from eight to fourteen days before we were in a condition to decide on the commercial value of the seed under trial.

"My attention was, however, directed to your excellent work, "On the Physical Phenomena of Nature," and I resolved to *put your theory to a practical test.* I accordingly had a case made, the sides of which were formed of glass coloured blue, or indigo, which case I attached to a small gas-stove for engendering heat; in the case shelves were fixed in the inside, on which were placed small pots wherein the seeds to be tested were sown.

"The results were all that could be looked for: *the seeds germinated in from two to five days only, instead of from eight to fourteen days as before.*

"I have not carried our experiments beyond the germination of seeds, so that I cannot afford practical information as to the effect of other rays on the after-culture of plants.

"I have, however, made some trials with the *yellow ray* in *preventing the germination of seeds,* which have been successful; and I have always found the *violet ray* prejudicial to the growth of the plant, *after germination.* I remain,

"My dear Sir,

"Very faithfully yours,

"To Robt. Hunt, Esq." "CHARLES LAWSON."

612. The Author of "The Reason Why" series, had the gratification of walking over the "trial grounds" of the firm of Messrs. Fraser, Richardson, and Goad, seedsmen and florists, 82, Bishopsgate Street, and was struck with the great care taken in testing every kind of seed, for the purpose of ascertaining its germinating quality, and consequent value. Thousands of little plots of seed, varying from one to four yards square, consisting of every variety of soil, were numbered, and a journal of all particulars—date when sown, state of the weather, time required to germinate, proportion per cent. vitalized, &c., precisely registered.

613. Mr. Fraser expressed the opinion that, *however interesting it might be as a scientific experiment to stimulate the germination of seeds by actinic rays,* yet, for the purposes of the cultivator of *agricultural crops, nothing could be so satisfactory as an out-of-*

"O, Thou, who in eternal light, unseen,
Surveyest, distinct, the universal scene!
Whose power, imparted, animates the whole
With vegetation, motion, life, and soul."—Boyse.

door trial, with all the natural elements in free operation. The following interesting particulars respecting the growth of seeds, and the duration of their vitality, are from Mr. Fraser's observations:—

614. The *Brassica tribe*, as *cabbage, kale, cauliflower, turnip, rape*, &c.: all these are similar in appearance of seed, and germinating qualities, and, if well ripened and harvested, will retain a growth of 90 to 100 per cent. unimpaired for from four to six years; then for a year or two diminish from 10 to 20 per cent. per annum; and generally speaking at the end of 10 or 12 years the vital power is almost exhausted.

615. *Carrot and parsnip* seed is much affected by season, and scarcely ever grows more than 70 or 80 per cent., and this only for one or two years at most. Three-year-old seed will rarely grow more than 10 or 20 per cent.

616. *Cucumber, melon, gourd:* well ripened plump seeds of these will germinate (though proportionately slower according to age,) at the end of 10 or 15 years. Many gardeners prefer old seed, the plants from them producing more fruit than from new seed.

617. *Lettuce* seldom grows more than 80 per cent., it being impossible to separate the imperfect seeds, they being in appearance equal to the very best. Its vegetative power is unimpaired for three or four years, and then diminishes in about same ratio as the brassica tribe.

618. *Peas* (garden), before vending, are all hand-picked by women, and should grow 100 per cent. They will grow equally well a second or even third year, the only effect being a proportionately slower germination. After the third year, they will not grow sufficiently for purposes of seed.

619. *Beans:* all the varieties will grow as well as peas, if of good samples; this a practical man can determine. After the first year they are comparatively useless for purposes of seed—changing colour and, with scarcely an exception, the germinating power diminished to the extent of near 50 per cent.

620. *Beet and Mangel Wurzel.*—There is no apparent variation in the germinating power of these seeds, whether one or seven years old; they have been known to grow well 10 years. Each seed contains

"Thy weedy fallows let the plough pervade,
Till on the top the inverted roots are laid;
There left to wither in the noon-tide ray,
Or by the spiky harrow cleared away."—SCOTT.

from two to four kernels, protected by a hard, rough, woody-like coating; each kernel, if perfect, will produce a plant. Thus from 100 seeds it is common to have a growth of from 200 to 300 per cent.

621. *Onion and Leek,* from cause stated in *lettuce,* grow but from 80 to 90 per cent., and this only for one year; the second thoy lose 10 to 15 per cent.; the third, still more; and at end of fourth year scarcely germinate.

622. *Radish,* when new, should grow 90 per cent.; it is a troublesome seed to keep, requiring constant attention to free it from *mites*; its germinating power diminishes 10 to 20 per cent. first year; second, still more; and at end of five or six years almost dies out.

623. *Parsley,* precisely similar to *lettuce, onion,* and *leek.*

624. *Clover, White,* also the same.

625. *Clover, Red,* grows rather better than white, and retains vitality a year or two longer.

626. *Grass seeds* being mostly light are seldom tested at per cent., and, excepting rye-grass, will scarcely vegetate a second year.

627. *How do we know that white light consists of a number of combined rays, of different colours and properties?*

Because white light may be *decomposed,* or separated into its elementary colours by *refraction.* The act of such separation is called the *dispersion* of the coloured rays. Each elementary ray, once separated from the rest, is *incapable of further decomposition* by the same means. The white light is *restored,* directly the coloured rays are *re-combined.*

628. *Why are grasses, leaves, flowers, and other bodies of different colours?*

The colours of natural bodies are not *inherent in the bodies themselves,* but are consequences of that peculiar

> "The same power that bids the mite to crawl,
> That browns the wheat-lands in their summer-stain;
> That Power which formed the simple flower withal,
> Formed all that lives and grows upon this earthly ball."—CLARE.

disposition of the particles of each body, by which it is *enabled more copiously to reflect the rays of one particular colour, and to transmit to the eye, or absorb into its own substance, the others.*

629. The direct action of solar light, or possibly of its heat also, produces various *chemical effects*, all indicative of powers resident in this wonderful agent, of which we have but a very imperfect notion at present. The green colour of plants, and the brilliant hues of flowers, depend entirely upon it. *Tansies*, which had grown in a coal-pit, were found totally destitute either of colour, or of their peculiar and powerful flavour; and the bleaching and sweetening of celery by the exclusion of light is another familiar instance of the same cause.*

630. If a mixture of equal volumes of *chlorine* and *hydrogen gases* be kept in the dark, no combination takes place between them; but in the light of day they unite slowly, and form hydrochloric gas, while, if exposed to the direct solar rays, the combination occurs instantaneously and with a loud explosion. In the same way, *chlorine gas* and *oxide of carbon*, when mixed, unite by the direct action of the sun's rays; but this effect is *not produced* by the agency of *heat*. The action of light on the *chloride of silver* is very remarkable, and it occurs very quickly. As long as this substance is kept from *light*, even though it be exposed to *heat*, remains perfectly *colourless*, but the sun's rays, and even diffused daylight, *blacken it speedily*. This effect is most strongly produced by the *chemical rays*, which impart *neither light nor heat*.†

631. *What are the principal effects of heat?*

By the effects of heat, a very considerable number of bodies, both solid and liquid, may be converted into the form of *gaseous matter*; and as long as that elevation of temperature continues, the form of an elastic fluid is retained. But in all such cases, a *depression of temperature* causes the elastic fluid again to assume the liquid or solid form from which it originally set out.

* Herschel. † Penny

"The Garden trees are hung with the shower
That fell ere sunset, now methinks they talk
Lowly and sweetly as befits the hour
One to another down the grassy walk."—A. H. HALLAM.

632. There is every reason to conclude that every solid in nature might be "melted by fervent heat," and by a high temperature, pass into the state of an elastic fluid. Heat has great power in modifying as well as causing *chemical action*, and different degrees of it produce very opposite effects, in some cases.

633. The essential distinction between *gas* and *vapour* may be thu stated: A *gas* is not reducible to the liquid state by any mechanical pressure *alone*, but must be operated upon by chemical agency also. A *vapour* of a given substance can contain only some definite quantity of that substance within a given volume, which quantity varies with the temperature.*

634. There are three forms in which a body may exist: the *gaseous*, the *liquid*, and the *solid*. A body that is elastic, like air, is called a *gas*; one that is inelastic, like water, a *liquid*; and one in which the particles do not readily move among each other, such as iron, wood, straw, feathers, a *solid*. Some bodies are capable of assuming ALL these forms at different temperatures, as water, for instance, is GASEOUS *above* 212°, LIQUID *from that down to* 32°, and SOLID *below that point*.†

635. *Why do we know that plants possess heat?*

It is understood that heat resides, in a greater or less degree, in *all* substances. Even in *ice* there is a certain amount of it, though quite imperceptible by the ordinary exercise of our senses.

636. But we know that plants possess heat, by various matters of observation. Snow *melts at the foot of a tree* sooner than at a distance from it.

637. Plants have the *power of resisting cold in winter*; and are protected from extreme cold by *having straw heaped against their trunks*. During every season of the year,

* Encyclopædia Metropolitana. † J. A. Nash.

trees absorb water from the earth; water, when absorbed, parts with its heat very slowly through the carbonated matter of the trunk. In winter, the temperature of the earth, which determines that of the water it contains, is uniformly higher than that of the atmosphere, and consequently, the temperature of the interior of a tree is also *higher*, in proportion to the difference of the heat of the soil, and that of the air. In the spring and summer, on the contrary, the earth is *cooler* than the air, and the temperature of vegetables is cooler also.

638. Independently of this source of heat in trees, there is another that deserves attention. *Whenever oxygen conbines with carbon to form carbonic acid,* an EXTRICATION OF HEAT TAKES PLACE, however minute the amount; such a combination occurs much more extensively during the *germination of seeds,* and the *impregnation of flowers,* than at any other time. At the first of these periods, extraction of heat takes place to a considerable amount, as is remarked in the germination of barley heaped in rooms previously to being manufactured into malt; in the latter it also occurs, but in consequence of flowers not being confined in close cases, it is lost as soon as it is disengaged.

639. *What are the laws that affect the diffusion of heat?*

Those laws of heat which *more particularly relate to agriculture and horticulture* are :—

1. Its *radiation,* which is the free motion of heat, exerted by it under all circumstances.

2. Its *reflection,* which is the turning back of rays of heat (in accordance with the law which governs the reflection of light), by surfaces upon which it falls.

3. Its *absorption,* or the power which substances possess

"Oft, notwithstanding all thy care,
To help thy plants, when the small fruitery seems
Exempt from ills, an oriental blast,
Disastrous flies."—J. PHILIPS.

of receiving and retaining the heating rays which impinge upon them, thereby acquiring an elevation of temperature.*

640. *Why are the slopes of mountains frequently hotter than the surfaces of plains?*

Because the sun's heat rays are *most powerful when they fall vertically* on any body. When the sun is at an elevation of 60° above the horizon, as is more or less the case toward noon in the middle of summer, the sun's rays frequently fall on them under a right angle, in cases where the slopes are yet larger.

641. If the actual increase of temperature produced by the perpendicular rays of the sun beyond the temperature in the shade be 45° and 63°, as is often the case in clear summer days, this increase would only be *half as great*, if the same light *spread itself in a more slanting direction*, over a surface twice as large.

642. *Why do dark soils become warm sooner than those of lighter shades?*

Because the *colours of bodies* exert *a considerable influence upon the amount of heat they absorb.* The darker coloured soils, such as the *black* and *brown* and *dark reds*, *absorb more heat* than the *grays* and *yellows;* and all dark-coloured soils *reflect the least*, whilst light coloured ones *reflect the most calorific rays.*

643. According to Schübler, while the thermometer was 77° in the shade in August, sand of a natural colour indicated a temperature of 112½°, black sand 123½°, and white sand 110°, exhibiting a difference of 13° of warmth, in favour of the black colour.†

* Encyclopædia Metropolitana.

† Stephens' Book of the Farm.

'O'er pathless plains at early hours,
The sleepy rustic slowly goes;
The dews, brushed off from grass and flowers,
Bemoistening, sop his hardened shoes."—CLARE.

644. *Why do dark soils, when heated, cool more rapidly than the other shades?*

Because dark colours *radiate their heat more rapidly* than light shades. Thus, *sand* will cool more slowly than *clay*, and the latter sooner than a soil containing much *humus.*

645. According to Schübler, a *peat soil* will cool as much in 1 hour and 43 minutes, as a pure clay in 2 hours and 10 minutes, and as a sand in 3 hours and 30 minutes. The practical effect of this difference is, that while the sand will retain its heat for *three hours* after the sun has gone down, and the clay *two hours*, the vegetable soil will only retain it for *one hour;* but then, the vegetable soil will all the sooner *begin to absorb the dew* which falls, and in a dry season, it may in consequence sustain its crops in a healthy state of vegetation, while those in the sandy soil may be *languishing for want of moisture.**

646. Pedestrians are well aware of the difference felt in a very hot sunshine in *walking over a white or dark soil.* In the first case the rays are reflected, and strike upon the body with uncomfortable force; in the second they are absorbed, and the ground, or rather air, appears to be cool and refreshing. The darker a soil, the greater its absorbing power; but, to compensate in some measure for this, the light-coloured soil retains heat longest.†

647. The reflection from a green field, perhaps, exceeds not the *twentieth part* of the whole incidence; but it increases considerably as the colour inclines to whiteness. From a smooth sandy beach, the reflected light will amount to the *third part* of what is received from the sky; and from a wide surface of snow, it will reach to *five-sixths* of the direct impression; the numerous facets of the bright snowy flakes which are presented in every possible position, detaining only

* Stephens's "Book of the Farm."

† Coleman's Prize Essay "On the Causes of Fertility and Barrenness of Soils." Journal of the Royal Agricultural Society.

"The vernal sun awakes
The torpid sap, detruded to the root
By wintry winds, that now in fluent dance,
And lively fermentation mounting spreads."—THOMSON.

one-sixth of the incident rays, and scattering the rest in all directions.*

648. *The more an earth weighs, the greater is its power of retaining heat.*

649. *The darker its colour, and the smaller its power of containing water, the more quickly and strongly will it be heated by the sun's rays.*

650. *The greater its power of containing water, the more has it in general the power also of absorbing moisture when in a dry, and oxygen when in a damp state, from the atmosphere.*

651. *When endued with a high degree of consistency, it is slow to become dry.*

652. *The greater the power of containing water, and the greater the consistency of a soil, the colder and wetter, of course, will that soil be, as well as the stiffer to work, either in a wet or dry state.*†

653. A remarkable variation of effect of the solar rays upon different substances, and of opposite colours, has been observed in the Arctic regions. Where the sun's rays fall upon the snow-clad surface of the ice, or land, they are in a great measure reflected, without producing any material elevation of temperature; but when they impinge on the black exterior of a ship, the pitch on one side occasionally becomes fluid, while ice is rapidly generated on the other.‡

654. *How is heat distributed over the surface of the earth?*

Chiefly through the movements of *air* and *water*. When the earth is heated by the sun's rays, the stratum of air resting on it, is expanded and rendered lighter by the heat which it absorbs, and consequently ascends, while colder air rushes in to take its place. The heated air is, by the pressure of the constantly ascending portions, forced towards a colder spot or climate; as it descends to supply the

* Leslie's "Heat and Moisture." † Schübler.
‡ Scoresby's "Account of the Arctic Regions."

"The vernal sun new life bestows,
E'en on the meanest flower that blows."—SCOTT.

equilibrium of the atmosphere, it *gives out the heat it had received*, and this serves to moderate the extremes of cold.

655. *Water* is not less useful in this respect. When a current of cold air passes over the surface of a large collection of water, it receives from it a quantity of heat, the specific gravity of the water is increased by cooling, and the cooled portion sinks. Its descent forces a portion of warmer water to the surface, which again communicates a quantity of heat to the air passing over it.* †

656. By such operations, every breath of air or movement of water tends to diffuse the essential agent heat, and to equalize temperatures to the condition requisite for organic life.

657. *What are the effects of electricity upon vegetable life?*

As far as investigation at present warrants a decision, FEEBLE *electricity* exerts no perceptible influence upon vegetable bodies; but its more VIOLENT effects are similar in their destructive nature to those produced by *lightning*.

658. The Abbé Bertholon was an enthusiastic advocate of the theory of electrical vegetation. He contended that electricity might be made beneficial in *stimulating the growth of plants;* and proposed an extensive system of horticulture. His plan contemplated the elevation of pointed conductors to a considerable height in the air, by which means a *supply of electricity* was to be obtained, and again *dispersed* from a series of points *over the growing produce of the garden*. This system has frequently been discussed and experimented upon,—among others by Dr. Ingenhowz and Mr. Cavallo,—but it has fallen into discredit.

659. So little has been satisfactorily ascertained, regarding the connection of *electricity* with the processes of vegetable growth, that

* Dr. Murray. † See the "Reason Why, Physical Geography."

"Each tree and flower in every hue
And varied green are spread,
As fair and frail as drops of dew
From off each blooming head."—CLARE.

it seems undesirable to dwell upon the manifestations of this agent which sometimes occur. It may be stated, however, that, whilst on one hand the condition of the atmosphere in regard to electricity has evidently a striking influence on the rapidity of their growth (some plants having been known to increase in the most extraordinary manner during electrical weather), the electricity developed by the changes which take place in the economy of plants, has probably a very powerful influence on the condition of the atmosphere. It is well known that by all chemical changes, such as occur in every process of vegetation,—from the absorption of the crude sap, to its final conversion into the substances which are to remain fixed or permanent through a long series of years,—electricity is produced. Further, the mere evaporation of water from the surface of the leaves will do the same; and thus a constant series of changes in the electric state of plants will occur, which will communicate themselves to the atmosphere.*

660. There is, however, an *indirect* way in which electricity proves highly beneficial to vegetation. The distinguished chemist, Cavendish, showed in 1781, that the *electric flash* MIGHT produce NITRIC ACID in the atmosphere. Liebig has since ascertained the *actual existence* therein of *ammonia.* Monsieur Barrat, having examined the rain-water collected at Paris, has found in every shower an amount of each substance, reaching, in the course of a year, the following quantities severally per English acre:—

			Nitrogen.
	lbs.		lbs.
Ammonia	12·29	=	10·69
Nitric acid	41·24	=	10·12

661. Still this large amount of manuring substance *might be derived by the atmosphere* of Paris *from the smoke and the fœtid exhalations* which float above every great capital, and much doubt was accordingly felt by continental chemists on the whole result of the investigation. It seemed desirable, therefore, to REPEAT THE EXPERIMENT IN PURE COUNTRY AIR. Accordingly rain-water was collected by me last October at Pusey, which is remote from any large town, except Oxford, from which the wind did *not* blow while the showers took place. It was analysed by Professor Way; and, supposing our annual

* Dr. Carpenter's "Vegetable Physiology."

"The various vegetative tribes
Wrapt in a filmy net, and clad with leaves,
Draw the live ether and imbibe the dew."—THOMSON.

fall of rain to be 28 inches, the amount of manure yearly poured down from the clouds on British soil would be larger than even at Paris. It would stand thus:—

		Nitrogen.	Nitrate of Soda.	Guano without Phosphates.
	lbs.	lbs.	lbs.	lbs.
Ammonia . . .	28·59 =	23·54 =	159$\frac{3}{10}$ =	164
Nitric acid . . .	68·91 =	17·88 =	121 =	124$\frac{6}{10}$
ANNUAL DOWNFALL OF MANURE PER ACRE . . .		41·42 =	280$\frac{3}{10}$ =	288$\frac{6}{10}$

662. Thus it appears that *in a year of ordinary rain* THE SKIES GIVE US AMMONIA AND NITRIC ACID EQUAL TO A FULL DRESSING OF SALTPETRE OR GUANO.

663. Much of each, especially the ammonia, is lost, perhaps, by exhalation from the surface of plants, or of the land, after slight showers. Enough, however, of both must remain to account for the *luxuriant growth* which sometimes *follows a thunderstorm*, and also to illustrate the Psalmist's expression that "the clouds drop fatness." *

664. *What are clouds?*

They are accumulations of *watery vapour* in the atmosphere, caused by evaporation from the surface of the *ocean*, from *wet and moist places* on the surface of the land, from the respiration and perspiration of *animals*, from the transpiration of watery fluids by *plants*, and some other natural operations.

665. Their manifold forms are the result of variations of *temperature*, movements of *air*, changes in the *electrical condition* of the air, the *degree of humidity* which prevails in the atmosphere, the *height at which they fly*, and the *situation they occupy*, in relation to the holder.

* Lord Ashburton, President of the Royal Agricultural Society.

668. Clouds constitute a sort of intermediate state of existence between vapour and water, by which *sudden depositions of water are prevented*. If all the water separated from the atmosphere fell AT ONCE to the earth, in the *state of water*, we should be *constantly liable to deluges, and other inconveniences*, the whole of which are obvaited by the present beautiful arrangement. Again, clouds are one great means by which water is transported from seas and oceans *to be deposited far inland*, where water otherwise would never reach.

* Schow's "Earth, Plants, and Man."

† Encyclopædia Metropolitana.

"In March is good graffing the skilful do know,
So long as the wind in the East do not blow;
From moon being changed, 'till past be the prime,
For graffing and cropping is very good time."—TUSSER.

Clouds also greatly *mitigate the extremes of temperature.* By day, they *shield vegetation from the scorching solar heat,* and produce all the agreeable vicissitudes of shade and sunshine. By night, the earth, wrapped in its mantle of clouds, is enabled to *retain that heat which would otherwise radiate into space,* and is thus protected from the opposite influence of *nocturnal cold.* Whether we contemplate clouds with respect to their form, their colour, their numerous modifications, or, more than all, their incessant state of change, clouds prove a source of never-failing interest, and may be classed among the most beautiful objects in nature.* †

669. The most important peculiarity of the *evaporation of water,* so far as we know, is *not at all affected by the water being frozen.* Howard, who experimented upon the subject, mentions an instance in the month January in a certain year, when the vapour form a circular area of *snow five inches in diameter,* amounted to 150 *grains* between sunset and sunrise; and before the next evening 50 grains more were added to the amount. Under like circumstances, a smart breeze operating at the time, an *acre of snow* would, in the course of twenty-four hours, evaporate the *enormous quantity* of 64,000,000 *grains of moisture!* Even by evaporation during the night only, *a thousand gallons of water would be raised from a acre of snow.* It may thus be easily understood, how a moderate fall of snow may entirely vanish during a succeeding northerly gale, *without the slightest perceptible liquefaction on the surface.* This will satisfy the reader of the fact, that *evaporation is constantly going on,* whether from *water, snow,* or *ice;* indeed there is every reason to believe, as before stated, *that the quantity of vapour formed from snow and ice, is precisely equal to what would be evaporated from water itself,* provided water could exist *as a fluid* below the temperature at which it is congealed.‡

670. *In what respects do clouds affect the growth of plants?*

Chiefly by the *dispersion of water* in the form of rain. But also—and in a very material manner—by the *radiation,* or *reflection,* of *heat* which *escapes from the earth* when the

* Dr. Prout. † See "The Reason Why: Physical Geography."

‡ Prout's "Bridgewater Treatise."

"And where the humid night's restoring dew
Dropt on the ground the bladed herbage grew,
As fast as cattle the long summer's day
Had cropt the grassy sustenance away."—FAWKES.

air becomes cool. They act as a *sort of screen*, shutting off the cold air, and *returning radiated heat.* They also *affect the quality of the light which passes through them*; but the nature of this last effect is not clearly understood.

671. The benefit resulting from rain depends not merely upon *the amount that falls annually*, but upon the proportions in which the fall is *distributed through the seasons.* It of course makes a great difference whether the same quantity of rain is distributed pretty equally through the seasons, or is accumulated into one season—the *rainy season*, in contrast to the remainder of the year, the *dry season.* The *frequency* of the fall of rain is another important point in the examination of the condition of the rains of a district or region. For it makes great difference in the climate whether *the same amount of rain* falls in MANY SMALL SHOWERS, or a FEW GREAT RAIN STORMS. Cayenne, in South America, has given an instance of as much rain falling in *half a day* as, on an average, falls in *half a year* in Copenhagen.

672. *What is the constitution of the atmosphere?*

It consists of *nitrogen gas, oxygen gas,* and *carbonic acid gas;* but with these are always combined matters which do not properly belong to the atmospheric compound, and which consequently vary in kind and quantity, such as *watery vapour, ammonia, carbonic acid gas,* and the other elements of evaporation, fermentation, and decay. The standard atmospheric substances and proportions may be thus given :—

	By measure.	By weight.
Nitrogen gas	77·5	75·55
Oxygen gas	21·0	23·32
Carbonic acid gas	0·80	0·10
Watery vapour	1·42	1·03

673. By *atmospheric watery vapour,* we are to understand a very rare, light, expansible body, capable, like air, of a reduction of volume

* Schow's "Earth, Plants, and Man."

'Parched meads and stubble mow by Phœbe's light
Which both require the coolness of the night."—DRYDEN.

by external pressure, and also of resisting any force which may tend to compress it. This vapour exists in every climate, and under every variety of temperature; in the frigid atmosphere of the polar zones, as well as in the burning regions of the equator; nor is there a particle of air uninfluenced by its presence, at least in the lower atmosphere, unless it be relieved from its agency by artificial means. This moisture, extensively as it is diffused, owes its origin to the waters which cover so large a portion of the globe, and which penetrating by a thousand channels, communicate some of their humidity to the earthy soil; and it is to the active agency of heat, that the rising moisture, the result of evaporation, is compelled to distribute itself throughout the different regions of the great aërial volume.*

674. *What is the composition of water?*

Water consists of *oxygen* and *hydrogen*, in the proportion of two volumes of the latter gas, to one of the former. It is capable of existing in three different states: the liquid, the aëriform, or solid—as water, vapour, or ice. When water contains *nothing but oxygen* and *hydrogen*, in their proper proportions, it is called PURE. But it is never *found pure* in nature; it is always combined with small portions of some other matters, which it has dissolved or taken up, in consequence of coming in contact with a great variety of soluble bodies. The different kinds of water receive names taken from the source from which they are derived. Thus we have *sea water*, *atmospheric water*, *river water*, *spring water*, *well water*, &c.†

675. *How does water act as a fertilizer?*

Pure water acts ONLY by its AIR. *Rain* water, however, acts in a double way, both by its *purity* and *impurity*. All water exposed to air, absorbs various proportions of *oxygen* and *nitrogen*. This is a very slow process. It is found that

* Encyclopædia Metropolitana. † Hugo Reid.

"Wide flush the fields; the softening air is balm;
Echo the mountains round; the forest smiles;
And every sense, and every heart is joy."—THOMSON.

most natural waters give out by boiling, from every 100 cubic inches of water, 3½ inches of air. This air contains eight or nine per cent. more oxygen, than an equal bulk of common air. Water is generally *filled or saturated with air;* when this is the case, it will take up no more by a month's exposure. If this water is boiled, and again exposed to air, it will absorb in twenty-four hours, as follows:—Let there be taken any number of measures of air, which are composed of 20 of oxygen, and 80 of nitrogen. If 100 measures are absorbed by water, it is in this proportion.

Of nitrogen	46·43
Of oxygen	53·57

So that oxygen is three times more absorbable than nitrogen.

676. *What is meant by the absorption of gases by water?*

It means this: that water can and does dissolve or absorb gases, as it does also solid bodies. In fact *it dissolves or combines with a little of every gas or air with which it comes in contact.* THIS IS A MATERIAL FACT FOR THE AGRICULTURIST: *that water constantly absorbs gases, and as constantly yields those gases, under certain conditions, to become the food of plants.*

677. All common water contains air; being in every situation much in contact with air, it dissolves part of it, causing it to assume the liquid form. In speaking of *gases* absorbed by, or in solution in water, the term "gas" expresses some substance which, when *uncombined,* exists in the *gaseous* form, though in the *liquid* state *when in union with the water.* When a glass of cold water from the spring is brought into a warm room, the inner surface of the glass is observed to be soon covered with a multitude of small globules of air, adhering to the sides and gradually rising to the surface. *This*

is the air which existed dissolved in the water, and was previously in the liquid state, being enabled to preserve this state by virtue of the attraction between water and air. But when warmed by the heat of the room, the elasticity of the air thus absorbed is increased, and disposes it to assume the gaseous condition, and, as the chemical attraction subsisting between the air and the water is not very great, it is overcome, and the air gradually separates from the water in small globules.*

678. *We may imagine from this what takes place after a shower of rain, or subsequently to the irrigation of land with water, or liquid manures. The water, warmed by the earth's temperature, and by free exposure to the sun, presents millions of little globules of gas to the absorbent organs of the roots which take up the nourishment thus supplied.*

679. All the foods of plants enter them, *either as invisible gases through the leaves, or in a state of perfectly limpid solutions, through the roots.* Now water will dissolve itself and hold in solution 3½ times its bulk of *oxygen,* 1½ its bulk of *nitrogen,* 1½ its bulk of *hydrogen* once its bulk of *carbonic acid,* and *many times* its bulk of *ammonia. In this way it conveys these and other nutritious gases as food into the plant.*

680. Water also dissolves solid substances, some more and others less, and *thus carries them in the form of transparent solutions into the plant, as food.* This office will appear the more important, when we consider that all growing plants *perspire largely.* They take up large quantities of water from the soil, appropriate to their own growth the nutritive matter dissolved in it, and then throw it off from their leaves by insensible perspiration.†

681. *Why are air bubbles frequently seen in lumps of ice?*

Because, when water is frozen, any gas which it contains, *separates from its chemical union with the water.* A great proportion of this escapes into the air during

* Hugo Reid. † J. A. Nash.

"Now let me tread the meadow paths,
While glittering dew the ground illumes,
As, sprinkled o'er the withering swaths,
Their moisture shrinks in sweet perfumes."—CLARE.

the freezing process; but when this is rapid, some of the gas becomes *imprisoned* in the ice. *Hence the globules* of gaseous matter which are frequently seen in blocks of ice.*

682. *Why does rain water possess highly fertilizing qualities?*

It is an ascertained fact that a quantity of *ammonia* and *nitric acid*, equal, perhaps, to at least *the manuring power of a hundred-weight of guano*, is annually brought down to the soil by rain, for the benefit of vegetation.

683. Let not, however, the cultivator deceive himself, and suppose that *the duty of manuring his soils is lessened* from this circumstance. The fall of manure—so to speak—it is out of his power to control; and to it is attributable, at least in part, the natural fertility of any given soil: his art lies in *increasing this natural produce* to a point at which the crops will repay the cost of their production. But he may profit by this newly-discovered bounty of nature, if he will take full advantage of the atmospheric manure by means of drainage, which promotes the equal flow of water THROUGH instead of OVER his soil; by deep cultivation and thorough pulverization of the land, which brings every part of it into contact with the air. The *atmosphere* is to the *farmer* like the *sea* to the *fisherman*—HE WHO SPREADS HIS NETS THE WIDEST WILL CATCH THE MOST.†

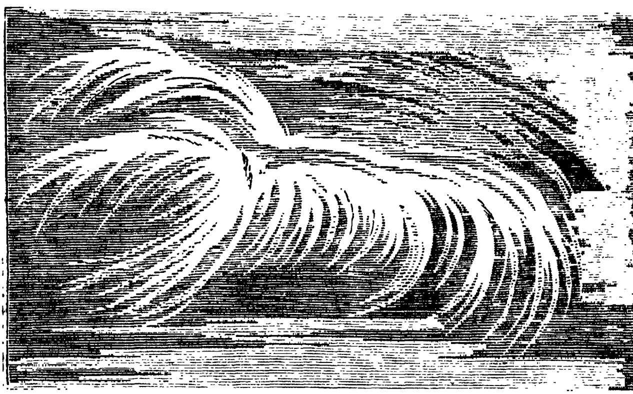
684. If a pound of rain water contains only *one quarter of a grain of ammonia*, then a field of 26,910 square feet must receive annually *upwards of eighty pounds of ammonia*, or *sixty-five pounds of nitrogen*; for, by the observations of Schübler, the fall of rain over that area must be about 2,520,000 in a year. This is much more nitrogen than is contained in the form of vegetable albumen and gluten, in 2,650lbs. of wood, 2,500lbs. of hay, or 200cwt of beet-root, which are the yearly produce of such a field; but it is less than the straw, roots, and grain of corn, which might grow on the same surface, would contain.‡

* Hugo Reid. † J. T. Way. ‡ Liebig.

"Beauty destined to endure
White, radiant, spotless, exquisitely pure
Through all vicissitudes, till genial Spring
Has filled the laughing vale with welcome flowers."—WORDSWORTH.

685. *What are the weather indications of "mare's tail" clouds?*

When their elevation is very great; when their forms are small, well defined, and thread-like, they *indicate wind.*



THE MARE'S TAIL.

686. When they become lower and denser, losing their curl-like form, and spread into long and dark streaks, becoming *wane clouds*, they indicate *wind and rain*, the near or distant approach of which may sometimes be estimated from their greater or less abundance and permanence.

687. *Mare's tail clouds* are generally first indicated by a few threads, pencilled as it were on the sky. These increase in length, and new ones are added to their sides. Often the first formed threads serve as stems which seem to support numerous branches, which in their turn give rise to others. They are the earliest clouds that appear after severe weather. Their duration is uncertain, varying from a few minutes after the first appearance to an extent of many hours. They are long when they appear alone, and at great heights, and shorter when they are formed lower, and in the vicinity of other

"If men would not exhale vapours to cloud and darken the clearest truths, no man could miss his way to heaven for want of light."—DECAY OF PIETY.

clouds. In fair weather, with light variable breezes, the sky is seldom quite clear of small groups of oblique curl clouds, which frequently come on from the leeward, and the direction of their increase is to windward. Continued wet weather is attended with horizontal sheets of this cloud, which subside quickly and pass into *wane clouds*. Before storms they usually gather in the quarter opposite to that from which the storm arises. Steady high winds are also preceded and attended by streaks running quite across the sky.*

688. *What are the indications of the pile cloud?*

These clouds are commonly of the most dense structure; they are formed in the lower atmosphere, and move along with the current which is next the earth.

PILE CLOUD.

689. The formation of large *pile clouds* to leeward in a strong wind, indicates the approach of a *calm with rain*. When they increase rapidly, and appear lower in the atmosphere, with their surfaces full of loose fleeces, they

* Howard's "Modifications of Clouds."

"Nature, attend! join every living soul,
Beneath the spacious temple of the sky,
In adoration join; and, ardent, raise
One general song!"—THOMSON.

indicate *rain.* When they do not disappear or subside about sunset, but continue to rise, *thunder is to be expected.*

690. The *pile cloud* generally appears at first as a small irregular spot, which is the nucleus on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps; which may afterwards continue long nearly of the same bulk, or rapidly rise to mountains. In the former case, they are usually numerous and near together, in the latter few and distant; but whether there are few or many, their bases always lie in one horizontal plane, and their increase upward is somewhat proportionate to the extent of base, and nearly alike in many that appear at once. Their appearance, increase, and decrease, in fair weather, are often periodical, and keep pace with the temperature of the day. Thus they will begin to form some hours after sun-rise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset. But in changeable weather, they partake of the vicissitudes of the atmosphere; sometimes evaporating almost as soon as formed, at others, suddenly forming and as quickly passing to the compound modifications. Independently of the beauty and magnificence of these clouds, they serve to *screen the earth from the direct rays of the sun,* and to *convey the products of evaporation to a distance from the place of their origin.**

691. *What are the indications of the sheet cloud, or creeping mist?*

The sheet cloud is the lowest of the clouds, its inferior surface commonly resting on the earth or water.

692. The sheet cloud has long been regarded as a prognostic of *fine weather,* and it is generally indicative of calmness.

693. Contrary to the *pile cloud,* which may be considered as *belonging to the day,* the sheet cloud is properly the *cloud of night;* the time of its first appearance being about sunset. It comprehends all those

* Howard.

"The dull-eyed Evening his moist vapours threw?
Strewing the still earth with sweet showers of dew."—DRAYTON.

creeping mists which in cold evenings ascend and spread in sheets (like an inundation of water) from the bottom of valleys, and the surface of lakes, or rivers, &c. Its duration is frequently through the night. On

SHEET CLOUD, OR CREEPING MIST.

the return of the sun, the upper surface of this cloud begins to put on the appearance of the *pile cloud*, the whole at the same time separating from the ground. The continuity is next destroyed, and the cloud ascends and evaporates, or passes off with the appearance of small *pile clouds*.

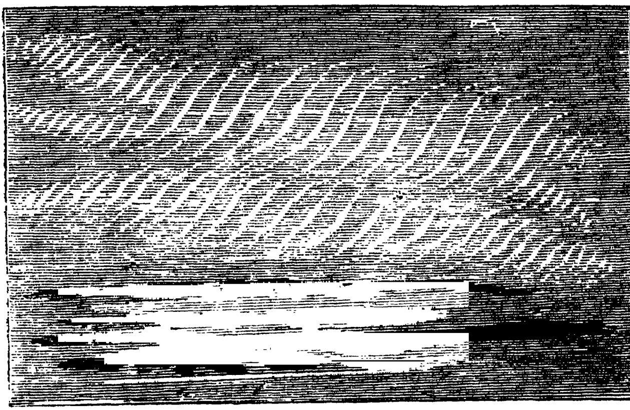
694. *What are the indications of the wane cloud?*

Wane clouds appear to arise from the subsidence of *mare's tails* to a horizontal position; but curl clouds do not always precede them. They are always thickest at one extremity, or in the middle. Their form and relative

* Howard.

> "What art thou first, and whence are thy keen stores;
> Is not thy potent energy unseen?
> Myriads of little salts, or hooked, or shaped
> Like double wedges, and diffused."—THOMSON.

positions, when seen in the distance, frequently give the idea of a shoal of fish.



A LIGHT AND A DARK WANE CLOUD.

695. At other times they appear like parallel bars, or interwoven streaks, like the grain of polished wood. They *precède wind and rain.* They are almost always to be seen in the intervals of storms.

696. Sometimes *wane clouds* and *sonder clouds* (next to be described) appear in the same sky, and even alternate with each other as parts of the same cloud, when the different evolutions which ensue afford a curious spectacle, and *a judgment may be formed of the weather likely to ensue, by observing which modification prevails at last.**

697. *What are the indications of the sonder cloud?*

Sonder clouds are usually formed by *curl clouds* collapsing, as it were, and passing into small roundish masses, in which the thread-like texture of the *curl* is no longer discernible.

* Howard.

"Religion wards the blow, or stills the smart,
Disarms affliction, or repels its dart;
Within the breast bids purest rapture rise;
Bids smiling conscience spread her cloudless skies."—COTTON.

698. These clouds are very frequent in summer, and

SONDER CLOUD.

attendant on *warm and dry weather.* They are occasionally seen in the intervals of showers, and in winter.

699. Sonder clouds form a very beautiful sky, sometimes exhibitin numerous distinct beds of small clouds, floating at different altitudes. The following passage is beautifully descriptive of their appearance by moonlight:—

For yet above these wafted clouds are seen
(In a remoter sky, still more serene)
Others, detached in ranges through the air,
Spotless as snow, and countless as they're fair;
Scattered immensely wide from east to west,
The beauteous semblance of a flock at rest.
These to the raptured mind aloud proclaim
Their mighty Shepherd's everlasting name.*

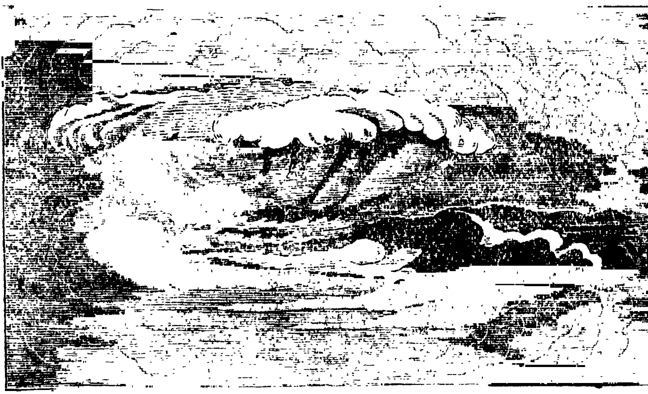
700. *What are the indications of the twain cloud?*

The different forms of clouds which have just been

* Bloomfield's "Farmer's Boy."

> "I did not err, there does a sable cloud
> Turn forth her silver lining on the night,
> And casts a gleam over this tufted grove."—MILTON.

described frequently give way to each other, at other times two or more appear in the same sky; and in this case the clouds which most resemble each other lie mostly in the



MIXED AND DISTINCT TWAIN CLOUDS

same place of elevation, those which are more elevated appearing through the openings of the lower, or the latter showing dark against the lighter ones above them. When the *pile cloud* increases rapidly, *wane clouds* are frequently seen to form around its summit, reposing thereon as upon a mountain. This state continues but a short time. The *wane clouds* speedily become dense and spread, while the superior part of the *pile cloud* extends itself and unites with the wane clouds, the base continuing as before, and the convex protuberances changing their position till they present themselves sideways and downwards.

701. Thus a large lofty dense cloud is formed, which may be compared to a mushroom, with a very thick short stem. But when a whole sky is crowded with this form,

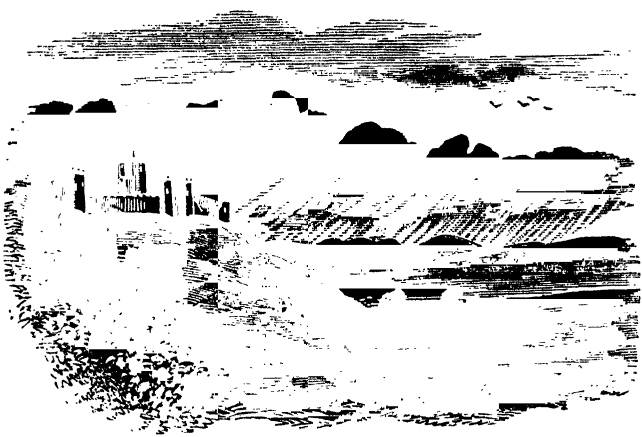
"Be calm, my soul, and cease repining,
Behind the cloud is the sun still shining."—LONGFELLOW

the appearances are never indistinct. The *pile cloud* rises through the interstices of the superior clouds, and the whole, seen as it passes off in the distant horizon, presents to the view fairy mountains covered with snow, intersected with darker ridges and lakes of water, rocks and towers, &c.

702. The distinct *twain-cloud* is formed in the interval between the first appearance of the fleecy *pile cloud*, and the *commencement of rain*, while the lower atmosphere is yet too dry; also during the *approach of thunder-storms*. The indistinct appearance of it is chiefly in the longer or shorter intervals of *showers of rain*, *snow*, or *hail*.*

703. *What are the indications of nimbus clouds?*

Nimbus clouds are attended by, or productive of,



NIMBUS, OR STORM CLOUD.

heavy showers, accompanied by *lightning* and *storm*.

* Howard.

"Then with uplifted hands, and eyes devout,
Grateful to Heaven, over his head beholds
A dewy cloud, and in the cloud a bow,
Conspicuous with three listed colours gay."—MILTON.

704. The *nimbus* generally spreads a sudden and almost impenetrable gloom over the horizon, in the direction from which the storm approaches. Although it is one of the least beautiful of the clouds, it is frequently superbly decorated with its attendant the *rainbow*, which can only be seen in perfection when backed by the widely-extended gloom of the storm cloud. The *nimbus* is known to be formed of *two two sheets of cloud*, in different electrical states, and hence it is so commonly attended with lightning and thunder.*

705. Clouds in any one of the preceding forms may increase so as to completely obscure the sky, and at times put on an appearance of density which, to the inexperienced observer, indicates the speedy commencement of rain. But, *before rain falls, the clouds are generally seen to undergo a change.* These appearances, when the rain happens over our heads, are but imperfectly seen. We can then only observe, before the arrival of the denser and lower clouds, or through their interstices, that there exists *at a greater altitude* a thin light *veil*, or at least a turbid haziness. When this has considerably increased, we see the lower clouds spread themselves till they unite in all points, and form one uniform sheet. The rain then commences, and the lower clouds arriving from the windward, move under this sheet, and are successively lost in it. When the latter cease to arrive, or when the sheet breaks, every one's experience teaches him to expect an abatement or cessation of rain. We see the nature of these processes most perfectly when viewing a distant shower in profile.†

706. As the masses of cloud are always blended, and their arrangement destroyed, *before rain comes on*, so the re-appearance of these is the signal for its cessation. The thin sheets of cloud, which pass over during a wet day, certainly receive from the humid atmosphere a supply proportionate to their consumption, while the latter prevents their increase in bulk. Hence it will sometimes rain for a long time without any apparent alteration in the state of the clouds. And here

* For an explanation of electrical phenomena, see "The Reason Why: General Science."

† Howard.

> "As the word's sun doth effects beget
> Different in divers places every day;
> Here Autumn's temperature, there Summer's heat,
> Here flowery Spring-tide, and there Winter gray."—DAVIES.

we find cause for reflection on the purpose answered by clouds in the economy of nature. Since rain may be produced by, and continue to fall from, the slightest obscuration of the sky by the *nimbus* (that is, by *two sheets* in different states), while the *pile* and *twain clouds*, with the most dark and threatening aspect, shall pass over without letting a drop fall, until their change of state commences, it should seem that *the latter are reservoirs in which the water is collected from a large space of atmosphere for occasional and local irritation in dry seasons,* space of atmosphere for occasional and local irrigation in dry seasons, and by means of which it is also arrested at times in its descent in the midst of wet ones, in which so evident provision for the sustenance of all animal and vegetable life, as well as for the success of mankind in that pursuit so essential to their welfare, in temperate climates, of cultivating the earth, we may discover the wisdom and goodness of the Creator and Preserver of all things.*

707. Chemistry can offer no satisfactory explanation regarding the formation of clouds; but, so far as researches have been carried, they tend to the conclusion that clouds do not consist of *actual drops of water*, but of myriads of minute and *thin vesicles of water*—like bubbles—thus they are enabled to hover at a small elevation for hours, and to transport their aqueous store far into the level of the country, or to the the tops of mountains, when the vesicles, suddenly breaking, and their watery films collapsing into drops, which the air cannot support, they fall in refreshing showers upon the earth.†

708. *Why do varying winds and temperatures prove beneficial to vegetation?*

Because they contribute to the *movement* of that *watery vapour* of the air, which is so intimately connected with vegetable and animal life.‡

709. It is computed that if the atmosphere as it exists at the equator were to discharge its whole watery store, the

* Howard. † Professor Griffiths.

‡ The indications of changes in the weather, including *haloes*, *mists*, *fogs*, *rainbows*, morning and evening *skies*, movements and cries of *animals*, flight of *birds* and *insects*, *weather proverbs*, &c., &c., are all fully explained in "The Reason Why: General Science."

' Now sliding streams the thirsty plants renew,
And feed their fibres with reviving dew."—POPE.

moisture precipitated would cover the surface of the earth only to the small depth of 7½ inches, and in the middle parallel, between the equator and the poles, only about 3½ inches. Supposing the whole atmosphere, from a state of absolute dampness, were to discharge its entire watery store, it would only form an uniform sheet of about 4½ inches in depth.

710. To furnish a sufficient supply of rain, therefore, it is necessary that the air should undergo *very frequent changes* from dryness to humidity in the course of a year.*

711. *What is dew?*

Dew is atmospheric moisture, which becomes *condensed by the cooling of the bodies upon which it rests.* It must be remembered that the air is *constantly impregnated with watery vapour,* and that this vapour becomes *rarified by heat* or *condensed by cold.*

712. As soon as the sun begins to sink, the earth, which has become heated by his direct rays, begins to cool. And dew begins to appear upon grass, in places shaded from the sun, during clear and calm weather, soon after the heat of the atmosphere has declined. The grass will frequently be found moist, in dry weather, several hours before sunset. But it is seldom present in such quantity upon grass as to exhibit visible drops before the sun is near the horizon, or very copious, till some time after sunset. It also continues to form in shaded places, after sunrise.*

713. *Why is dew more plentiful in spring and autumn than in summer?*

Because a greater difference is generally found between *the temperatures of the day and the night,* in the former seasons of the year than in the latter.*

* Leslie. † Dr. Wells "On the Formation of Dew."

"I must go seek some dew-drops here,
And hang a pearl in every cowslip's ear."—SHAKSPEARE.

714. *What is the movement of heat called, by which bodies become cooled?*

The throwing off of heat is called *radiation.* Imagine an iron ball heated to redness, and suspended by a chain; it will throw of rays off heat in every direction. *All bodies that are heated to a degree above that of the medium which surrounds them, part with heat in this manner, whether those bodies be leaves, feathers, wool, hair, wood, stones, or metal.**

715. *Why on a dewy morning are some bodies wetter than others?*

Because, although all bodies radiate heat, they do not all do so *in the same degree,* Some, therefore, *become cooler than others,* and those which part with the *most heat* condense the *greatest amount of moisture* from the surrounding air.

716. Difference in the *mechanical* state of bodies, though all other substances be similar, has *likewise* an effect on the quantity of dew which they attract. Thus, more dew is formed upon *fine shavings of wood,* than upon a *thick piece* of the same substance. It is chiefly for a similar reason that *fine raw silk, fine unwrought cotton,* and *flax,* are found to attract more dew than *wool,* the fibres of which are thicker than those of the substances just mentioned.*

717. *Why are cloudy nights less dewy than those that are clear and star-lit?*

Because the clouds *intercept* and *check* the radiation of the earth's heat; they also themselves *radiate heat towards the earth,* and prevent the temperature of earthy bodies from falling to a degree below that of the atmosphere which intervenes between the clouds and the earth. *They constitute, in fact, an expanded screen, or curtain between the earth and the remote sky.*

* Dr. Wells.

"He, therefore, timely warned, himself supplies
Her want of care, screening and keeping warm
The plenteous bloom, that no rough blast may sweep
His garlands from the boughs."—COWPER.

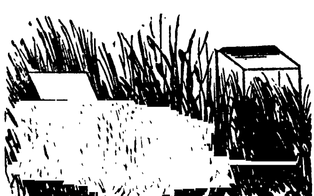
718. But when this curtain does not exist—*when the sky is clear*, and, consequently, the stars may be seen—the radiated heat of the earth *passes freely away*, and the bodies upon its surface becoming colder than the surrounding atmosphere, *condense the moisture* which the latter contains, and form *dew-drops*.

719. The degree of heat radiated from the clouds must in some degree depend upon their *density* and their *altitude*. Dense clouds, *near the earth*, must possess the same heat as the lower atmosphere, and will, therefore, send to the earth as much, or nearly as much, heat as they receive from it by radiation. But similarly dense clouds, *if very high*, though they equally intercept the communication of the earth with the sky, yet being, from their elevated situation, colder than the earth, will radiate to it less heat than they receive from it, and may, consequently, admit of bodies on its surface *becoming colder than the air*.*

720. *Why do screens of matting, &c., protect plants from cold?*

Because they act as *screens* preventing the *escape of radiated heat*, and also directing a portion of their own heat radiation towards the object they are designed to protect.

721. If plates of glass, sheets of paper, or pieces of cloth, be laid over grass-beds, as in the engraving, no dew will be deposited on the grass underneath the glass plates, although all around the grass will be completely wetted. The explanation is, that the glasses, being radiators of heat, *act in the same manner as the clouds*, returning the heat to the bodies underneath them, and preventing the formation of dew thereon. In a similar way



is *partly* to be explained the manner in which a layer of straw

* Dr. Wells.

"And that by certain signs we may presage
Of heats, and rains, and winds' impetuous rage,
The Sovereign of the Heavens has set on high
The Moon, to mark the changes of the sky."—DRYDEN.

preserves vegetable matters in fields from the injurious effects of cold in winter.*

722. *Why is it believed in some parts of the world that moonlight promotes putrefaction?*

Moonbeams comunicate no sensible heat to the bodies on which they fall, and it seems, therefore, *impossible* that they can *promote putrefaction.* But a reason for ascribing to them such a power, may be derived from their being received by animal substances *at the very time that a real cause of putrefaction is taking place.*

723. The nights on which a steady moonshine occurs, must necessarily be *clear*; and nights which are clear are almost always calm. A moonlight night, therefore, is one *on which dew forms plentifully*; and it is the *moisture of the dew* acted upon by the returning *warmth of day*, which *produces the putrefaction attributed to moonlight.*†

724. The opinion that *moonlight promotes putrefaction* is entertained in the West Indies, and in Africa, and was probably carried thence by negroes to America. It was entertained by persons of considerable rank and intelligence among the ancients—Pliny affirming it to be true, and Plutarch admitting it to be well founded.

725. *Why are the upper parts of leaves, &c., generally covered with dew, while their lower portions are free from it?*

Because the surfaces which are turned towards the earth maintain an elevated temperature by mutual radiation: such surfaces *receive the radiated heat of the earth,* and *give back rays of heat towards the earth.* Hence the grass which grows beneath trees with expanding branches, will be found less wet with dew than the grass which grows away from the influence of the branches.

* "The Reason Why: Familiar Science." † Dr. Wells.

"He beheld a field,
Part arable and tilth; whereon were sheaves
New reaped; the other parts sheep-walks and folds."—MILTON.

726. It has been observed that sheep that have lain on the grass, during the formation of dew, have *their backs* completely saturated with it, but that underneath the line *where their bodies turn to the earth,* their coats are dry. In the same manner glass globes suspended in the air, on dew-forming nights, will be found loaded with globules of dew upon the top, but there will be no appearance of moisture underneath.*

727. *Why is the grass plot frequently wet with dew, while the gravel walk, which lies by its side, is free from it?*

Because the grass, *being a better radiator than the gravel,* falls to a lower temperature and condenses more of the moisture from the surrounding atmosphere.

728. One general fact relative to the situation of bodies, and the amount of dew that they receive is, that *whatever diminishes the view af the sky, as seen from the exposed body, occasions the quantity of dew which is formed upon it, to be less than would have occurred if the exposure to the sky has been complete.*

29. All substances which present *a great amount of surface* in proportion to their matter, are good radiators, the surface offering, as it were, the outlet to the rays of heat. Thus, a *solid block of wood* radiates heat indifferently, and forms comparatively little dew upon its surface; but the same piece of wood *cut into shavings,* would radiate heat freely, and every part of its exposed surface become literally wet with dew. In this we find a beautiful and wise provision by which dew is formed upon leaves of plants, the petals of flowers, and open and porous soils *to which it may be beneficial;* while from stones, solid rocks, and metals, *to which it could be of no use,* it is wisely withheld.†

* "The Reason Why: Familiar Science." † Dr Wells.

"Nor God alone in the still calm we find;
He mounts the storm, and walks upon the wind."—DENHAM.

730. *Why is a slight movement of the atmosphere favourable to the formation of dew?*

Because fresh volumes of air are thereby brought successively in contact with the cooling surfaces, and remain long enough in contact with them for some portion of the moisture to be condensed. The cooling surfaces, therefore, receive constant *additions* of dew.

731. In *very calm* nights, a portion of air, which comes in contact with cold grass, will not, when the surface is level, immediately quit it, more especially as this air has become specifically heavier than the higher, from a diminution of its heat, but will proceed horizontally, and be applied unceasingly to different parts of the same surface. The air, therefore, which makes this progress, must at length have no moisture to be precipitated, unless the cold of the grass which it touches should increase.*

732. *Why is little dew formed on windy nights?*

Because the air being in rapid motion, *does not remain long enough in contact* with cooling surfaces to deposit its moisture. Winds, also, are generally drying, and tend to *absorb moisture.*

733. Bodies exposed in a clear night to the sky, must radiate as much heat during the prevalence of wind, as they would do, if the air were altogether still. But in the former case, little or no dew will be observed upon them, because *their degree of cold cannot differ greatly from that of the atmosphere,* as the frequent application of fresh air must constantly tend to equalize the temperature.*

734. *Why is dew less copious upon hills than upon plains?*

Because the air of high places is *much more agitated,* or more frequently in the condition of *wind.* The

* Dr. Wells' "Essay on Dew."

"The imprisoned worm is safe
Beneath the frozen clod; all seeds of herbs
Lie covered close and berry-bearing thorns
That feed the thrush."—C———

frequent removal, therefore, from this cause, of the air in contact with the grass on the hill, will prevent it from ever becoming much colder than the general mass of the atmosphere, at the same height.

735. What has been already said, refers only to what occurs on the very *summit* of the hill. With respect to its *sides*, these can only be a little colder than the atmosphere upon a level with them, even in the calmest state. For, in the first place, they do not enjoy the full aspect of the sky; and, in the second, the air, which is cooled by contact with them, will, from its increased gravity, slide down their declivity, and thus make room for the application of *new and warm volumes to the same surface.**

736. *Why do the leaves of trees often remain dry throughout the night, while those of grass are covered with dew?*

Because the air in the higher situation is *more agitated* than on the ground. The air at a little distance from the ground, being *nearer to one of its sources of moisture,* will, on a calm evening, contain *more of it* than that which surrounds the leaves of elevated trees. And the declension of the leaves from a horizontal position will occasion the air, which has been cooled by them, to *slide quickly away,* and be succeeded by warmer particles.

737. The length of the branches of trees, the tenderness of the twigs, and the pliancy of the footstalks of their leaves, will cause in the leaves an almost perpetual motion, even in the states of air that may be denominated calm. Hence we frequently hear, during the stillness of night, a *rustling noise* in trees, while the air below seems *without motion.*

738. *Why should the agriculturist pay considerable regard to the theory of dew?*

Because it forcibly impresses him with the fact that

* Dr. Wells.

"When ploughing is ended, and pasture not great,
Then stable thy horses, and tend them with meat:
Let season be dry, when ye take them to house,
For danger of nits, or for fear of a louse."—TUSSER.

the atmosphere is *constantly impregnated with watery vapour*, which, in its gaseous state, *accompanies the air wherever it penetrates, permeates the soil, pervades the leaves and pores of plants*, and gains admission into the lungs and general vascular system of all terrestrial animals. From these circumstances, the practical farmer may derive many advantages.

739. He will perceive, from the constant presence of this vapour, the reason why the air *should be allowed to circulate freely even in the dryest weather, through a well-pulverized and loosened soil*, about the roots of all growing crops, gradually administering to their wants by *letting in moisture*, instead of *letting it out*, as is sometimes erroneously supposed.

740. It is chiefly when it assumes the form of *rain, snow, hail*, and *dew*, that the benefits arising from a previous *conversion of water into vapour* are to be particularly appreciated by the husbandman.*

741. Many of the compound earths and stones possess the power of *attracting moisture from the air*, in a high degree. The absorbent power of earths depends as much on their *mechanical condition*, as on the *species of matter* of which they are composed. Whatever tends to harden them, diminishes the measure of effect; and hence apparently, the reason why the action of fire destroys their drying qualities. Quartz, or silica, which in a blacksmith's forge had suffered a reduction to 19°, after being soaked in water for the space of a week and again dried, showed an effect equal to 35°, and would probably in time have recovered the whole of its original power. The process by which nature gradually divides, softens, and disposes stony bodies to absorb moisture, is beautifully illustrated in the case of our whin-stone, or trap. A piece of solid trap produced a dryness of 80°; another piece, decayed and crumbling, gave 86°; but another

* D. J. Browne.

"He shades the woods, the valleys he restrains
With rocky mountains, and extends the plains."—DRYDEN.

piece of the same rock, already reduced to mould, afforded 92°. The ameliorating influence of culture is exemplified in sea-sand: fine sand caused a dryness of 70°; sand collected from the paths of a sheep-walk near the beach, 78°; and the same sand, lately brought into cultivation, 85°. Still, these effects are inferior to that of garden mould, which amounts to 95°, and to which decomposed trap approaches the nearest. Other cultivated soils exert a similar power of absorption, and which appears always proportioned to their respective goodness. Nor are such increased energies to be ascribed to the amelioration from manure, *since this ingredient separately has less influence than the earths themselves.* It therefore seems highly probable, that the fertility of soils depends chiefly on their disposition to imbibe moisture.*

742. *What is hoar frost?*

Hoar frost is *frozen dew.* This beautiful phenomenon appears to result from the condensation of atmospheric vapour into exceedingly minute drops, and *the slow congelation of these into crystalline particles more attenuated than those of snow flakes.* These crystalline particles are received by leafless branches, evergreens, blades of grass, roofs, fences, stakes, and other solid objects which act as points of supports.†

743. *Why does frost benefit ploughed lands?*

Because soils consist of an aggregation of earthy matter, *débris* of various rocks, portions of which always consist of *undecomposed stone.* Bodies of this nature exposed to the air and moisture, absorb water, which enters into the interstices and crevices between the atoms of the masses, or into the pores of the raw clots of earth.

744. When frost takes place, the absorbed water

* Leslie. † Professor Griffiths.

745. So long as the frost lasts, these particles are all *bound together* by the enveloping ice, but *immediately when thaw comes*, they separate and fall apart, then the lump which before showed but one surface to the air, has now a multitude of surfaces, and the atmosphere acts upon it *in an infinitely multiplied degree.*

746. The property of condensing some important gases within a porous body, is *in proportion to the extent of superficies that the gas can meet with:* the crumbling down of the particles of the soil is therefore, even in this respect alone, an important feature; the earthy salts of the soil are also thereby more extensively exposed to the action of the atmospheric influences in bringing about beneficial changes in their constitution.*

747. The action of frost is very important, the expansion of the moisture in the soil or rock breaking up the particles, and PREPARING THE WAY FOR THE CHEMICAL FORCES TO ACT; these are chiefly the oxygen of the air, and carbonic acid gas, dissolved in rain-water; both possess powerful affinities for many mineral substances—*oxygen* forming *oxides*, generally more soluble, and looser in nature, than the original minerals; *carbonic acid* acting upon *lime*, *magnesia*, and the *alkalies*, destroying previous combinations, and forming *soluble carbonates.*†

748. *Why is it said that "snow is the poor man's manure?"*

This familiar proverb, like others of its class, rests upon observation, and is confirmed by experiment, which demonstrates *the existence of certain fertilizing salts in snow.*

* T. F. Jamieson, Journal of Royal Agricultural Society, Vol. XVII.
† John C[illegible]

"This is the state of man: to-day he puts forth
The tender leaves of hope, to-morrow blossoms,
And bears his blushing honours thick upon him;
The third day comes a frost—a killing frost."—SHAKSPEARE.

749. In 1751, Margraf, in the neighbourhood of Berlin, after it had snowed several hours, collected in glass vessels as much *falling snow* as afforded 3,600 ounces of *water*. This carefully evaporated, afforded 60 grains of *calcareous matter*, with some grains of *muriatic acid*, and traces of *nitrous vapour*. An equal quantity of *rain water*, afforded 100 grains *calcareous matter*, with some *muriatic acid;* and in both cases the matter was discoloured by an oily substance.

750. A similar result was obtained long ago in Ireland, by Dr. Rutty, who found in a gallon of *snow water*, 4 grains, and in one gallon of *rain water*, 6 grains of *calcareous matter*. This is about the proportion found by Margraf, and *would give for each inch of snow water about* 10*lbs. of salts per acre*. From the existence of *free acids* in this case, it is evident that no *carbonate of ammonia* could have been present

751. There are some experiments performed by Dr. Williams, formerly Hollis Professor of Mathematics and Natural Philosophy, in Harvard College, U. S., and detailed in the first volume of his history of Vermont, where the experiments were performed. In 1791, 6 gallons of fresh falling *snow water*, afforded by evaporation, 11 grains *calcareous matter*, 2 grains of *saline matter*, 5 grains of a *dark-brown oily matter*. In January, 1792, 6 gallons of *snow water*, from snow lying three inches deep on the grass, on an area of 16 square feet, where it had lain 59 days, covered with a depth of 27 inches of snow, afforded the same salts as above, and 105 grains of this oily matter. This is the most remarkable fact, and may afford some weight to the suggestion before made, *that organic matter exists gaseous in the air*. It must have been drawn up by capillary attraction, or evolved from the surface of the earth. It is there *condensed by the snow*, and returned to the earth, impregnated with its *salts of lime* and *ammonia*.*

752. *Why does snow "keep the earth warm?"*

Because it is a *bad conductor of heat*, and prevents the cold air from *depriving the earth of its warmth*. It *prevents the radiation of the earth's heat*. When we reflect upon

* Dr. S. L. Dana.

"Behold the groves that shine with silver frost,
Their beauty withered, and their verdure lost."—POPE.

the warmth of snow, and examine the chemical constitution of frost and hail, we must be struck with the beauty and truth of that passage of Scripture which says—"He giveth *snow* like *wool*: he scattereth the *hoar frost* like *ashes*."

753. *What is hail?*

Hail is the *frozen moisture of the clouds*. It is probably formed by *rain drops*, which have accumulated in size by addition on their way to the earth, meeting with an *exceedingly cold current of air near to the earth*, by which they become *suddenly frozen into hard masses*. It is also supposed that the electrical state of the air *influences the formation of hail*.

754. From the examination of *hail-stones*, by Girardin, a French chemist, it appears that no sensible trace of ammonia was detected during the evaporation of their water, but there was found a notable quantity of *lime* and *sulphuric acid*; and above all, a large proportion of *an organic substance containing nitrogen*. Melted hail-stones have the appearance of water, containing a drop or two of milk; by standing, the water grows clear, and the flocky matter which settles, burns with the smell of *animal matter*, and evolves *ammonia*.*

755. *Why do forests lower the temperature of the localities in which they exist?*

Because they *detain and condense the clouds as they pass*; they pour into the atmosphere *volumes of water* dissolved in vapour. Winds do not penetrate into their recesses; the direct sun never warms the earth they shade; and the soil, being porous, as found in part of the decayed leaves, branches, and stems of trees, and coated over besides by a thick bed of brushwood and moss, is constantly in a state of

* Dr. S. L. Dana.

" How vapours turned to clouds obscure the sky,
And clouds dissolved, the thirsty ground supply."—ROSCOMMON.

moisture. The hollows in them serve as reservoirs for cold and stagnant waters; their declivities give rise to numberless brooks and rivulets; the best wooded countries being those which are watered by the largest rivers.*

756. *Why are mountainous localities more rainy than flat ones?*

Because the mountains *attract* the clouds; and because the clouds that are flying low are borne against the sides of the mountains and *directed upwards* into the *cold regions*, where, the vapours *becoming condensed* by the lower temperature, descend as *rain.*

757. *Why do mushrooms, and other funguses, grow most abundantly in moonlight?*

Because *yellow light* is favourable to the growth of these plants. Heat, in the force in which it resides in the solar rays, is unfavourable. The *heat* of the rays of the moon is very limited, and the amount of *chemical action* is exceedingly small. We must, therefore, regard the moonbeams as consisting largely of the *luminous* rays, the other active rays being, in all probability, absorbed by the moon's surface.†

758. *Why is moonlight said to be cold?*

Because it occurs in the season of *nightly radiation*, when

* Gower's "Scientific Phenomena." † Hunt's "Researches on Light."

"By nature shaped to various figures, those
The fruitful rain, and these the hail compose;
The snowy fleece and curious frost-work, these
Produce the dew, and those the gentle breeze."—BLACKMORE.

all bodies have a tendency to cool, by throwing off the heat they have absorbed during the day. As this occurs chiefly when the sky is clear and calm, the temperature of the *air* frequently falls to 40° or 43° Fahr., and at this temperature a plant, *radiating into space*, readily falls below the point of congelation, and then the hopes of the gardener and farmer are sometimes destroyed. The phenomenon takes place particularly in a bright night, and *if the moon happen to be up when it occurs*, the influence *is ascribed by the uninformed to her light*. Were the sky *clouded*, the principal condition of radiation would be wanting; the temperature of objects on the surface of the ground would not fall below that of the surrounding medium, and *plants would not freeze unless* THE AIR ITSELF fell to 32° Fahr.

759. The observation of gardeners upon the "*coldness of moonlight*" is not in itself *false*, but only *incomplete*. If the freezing of the soft and delicate parts of vegetables, in circumstances when the air is several degrees above the freezing point, be really due to the *escape of heat* into planetary space, it must happen that a screen placed above a radiating body, so as to mask a portion of the heavens, will either prevent, or at least diminish, the *amount of cooling*. And that this takes place, in fact, appears from the beautiful experiments of Dr. Wells. A thermometer, placed upon a plank of a certain thickness, and raised about a yard above the ground, *occasionally indicates in clear and calm weather* from 6° to 7° or 8° Fahr. *less than a second thermometer attached to the* LOWER SURFACE *of the plank*. It is in this way, as we have seen, that we can explain the *use of mats*, of *layers of straw*, and all those slight coverings which gardeners are so careful to supply during the night to delicate plants at certain seasons of the year.

760. The screens indicated, as simple as they are effectual in protecting plants in the *garden*, are rarely applicable in *farming*, where the surface to be preserved is always very extensive. Nevertheless, in severe winters, the frost, by penetrating the ground, would frequently destroy the fields sown in autumn, were it not that in

"That screened the fruits of the earth and seats of men,
From cold Septentrion blasts."—MILTON.

high latitudes *the snow which covers the surface* becomes a powerful obstacle to excessive cooling, *by acting at one and the same time as a* COVERING, *and a* SCREEN *preventing radiation.*

761. When we reflect upon the losses occasioned to farmers and market gardeners by *frosts that are entirely due to nocturnal radiation* at seasons of the year when vegetation has already made considerable progress, we ask eagerly *if there be no possible means of guarding against them?* There is a method successfully followed by the South American agriculturists with this view. The natives of the upper country in Peru, who inhabit the elevated plains of Cusco, are perhaps more than any other people, accustomed to see their harvest destroyed by the effects of nocturnal radiation. These people appear to have ascertained the conditions under which frost during the night was most to be apprehended. They had observed that it only froze when the night was clear and the air calm; knowing, consequently, *that the presence of clouds prevented frost, they contrived to make artificial clouds to preserve their fields against the cold.* When the evening led them to apprehend a frost—that is to say, *when the stars shone with brilliancy,* and the air was still—*the Indians set fire to a heap of wet straw or dung, and by this means raised a cloud of smoke, and so destroyed the transparency of the atmosphere from which they had so much to apprehend.* It is easy, in fact, to conceive that the transparency of the air can readily be destroyed by raising a smoke in calm weather; it would be otherwise were there any wind; but then the precaution itself becomes unnecessary, for, with *air* in *motion,* there is *no reason to apprehend frost from nocturnal radiation.**

* Boussinghault's "Rural Economy."

"Some useth at first, a good fallow to make,
So sow thereon barley, the better to take,
Next that to sow pease, and of that to sow wheat,
Then fallow again, or lie lay for thy neat."—TUSSER.

III.

AGRICULTURAL PRACTICE: PLOUGHING, FALLOWING, MANURING, SOWING, DRILLING, DIBBLING, HARROWING, WEEDING, HOEING, HAYMAKING, REAPING, STORING, ROTATION, FENCING, DRAINING, &c., &c.

762. *Why should the speed of horses at the plough be carefully and evenly regulated?*

Because, when horses are driven *beyond their step*, they *draw very unequally*, and, of course, the *plough is held unsteadily*. In that case, the plough has a tendency to *take too much land;* to obviate which, the ploughman *leans the plough over to the left*, in which position it raises *a thin broad furrow-slice* and *lays it over at too low an angle.*

763. On the other hand, *when the ploughman allows the horses to move at too slow a pace*, he is apt to *forget what he is about*, and the furrow slices will then, most probably, *be made too narrow and shallow;* and though they may be laid over at the proper angle, and the work appear externally well enough executed, *there will be a deficiency of mould in the ploughed soil.**

764. *Should cattle be yoked to a plough in pairs, or in a single line?*

There are *advantages and disadvantages attending each*

* Stephen's "Book of the Farm."

> "Go plow up or delve up, advised with skill,
> The breadth of a ridge, and in length as ye will;
> Where speedy quickset for a fence ye will draw,
> To sow in the seed of the bramble and haw."—TUSSER.

way; and the only method of arriving at a just conclusion is to compare these, and apply the deduction to such special circumstances as may exist.

765. A disadvantage of yoking *in pairs* is, that in ploughing the furrows betwixt the ridges, the land-cattle *go upon the ploughed land, and tread it down with their feet;* this, especially *if the land is wet,* hurts it very much. Another disadvantage is, that when there is but as much of the ridge unploughed as to allow the land-cattle to go upon it with difficulty, they are frequently either going into the opposite furrow, and thereby *giving the plough too much land;* or, which is worse, they are *justling the furrow cattle upon the ploughed land.*

766. *When cattle are yoked in a line,* they go all in a furrow. This makes it necessary to *give the plough more land than ordinary.* Another disadvantage is, that horses and oxen, like men, *love their ease,* and are disposed to *throw the burden upon their fellows.* This they have a better opportunity of doing when yoked in a line before each other than when in pairs. When yoked in a line, each pulls by the traces of the one behind him; and therefore, though it may be known when the *foremost* neglects his work, by the *slackening of his traces,* yet it cannot be known, except by close observation, *when any of the rest neglect their work.*

767. There is another inconvenience attending the common way of yoking cattle in a line before each other. When the fore-cattle are all yoked to the traces of the hindmost, it is obvious, that as the beam to which the draught is fixed, is much lower than his shoulders, by which the rest pull, such a weight must be laid upon his

"The dawn is over-cast, the morning lowers,
And heavily in clouds brings on the day."—ADDISON.

back or shoulders as must render him incapable of giving any assistance. When a body is to be moved forward, the nearer the direction of the force applied approaches to the direction of the body, it acts with the greater influence; and therefore, as the plough moves horizontally, and as the direction of the united draught of a plough with the cattle yoked two abreast is more horizontal than the direction of the draught in a plough with the cattle yoked in a line, *the same force applied* will have *greater influence.*

768. But this is *easily discovered,* when the cattle are yoked in pairs; for every one of them has then a *separate draught.* The goadman knows by the position of the yokes or cross-trees, whenever one of them does not draw equally well with his fellow; and the ploughman perceives, by the going of the plough, whenever either of the two pairs does not draw equally with the other; for if the pair that goes foremost neglect their work, the plough is *pulled out of the ground;* and if the pair that go hindmost neglect their work the plough is *pulled in too deep.*

769. *When these different ways of yoking cattle in ploughs are considered and compared,* it is difficult to determine which ought to be preferred. Each seems *preferable to the other in a certain situation.* When the *land is stiff,* and the labour severe, yoking the cattle *in pairs* seems preferable, as it is the strongest draught; and when the *land is wet and in danger of much hurt by the treading of the cattle,* the yoking them *in a line* confines them to the *bottom of the furrow and prevents a great amount of harm.**

770. *When horses are yoked in a line,* if the traces of the horse next but one to the plough are made *very long,* and fixed, not to the *shoulders* of the horse, but to the *cross-tree,* and the traces of the horse before him, not to his shoulders, but to his *traces,* where the back rope is fixed, the hindmost horse will be releived from the burden pointed out as a disadvantage.* The traces being long will incommode the hindmost horse *in turning,* which may be obviated by

* Dickson "On Agriculture."

"Fancy, with prophetic glance,
Sees the teeming months advance;
The field, the forest, green and gay,
The dappled slope, the tedded hay."—WARTON.

two links fixed to his shoulders, the traces being passed through the links, and the latter long enough to allow the traces to be stretched.*

771. A Scotch ploughman of great experience and judgment expressed to Mr. Pusey the opinion *that two horses abreast have as much power over the plough as three horses in a line, because their "purchase" over it is greater in that proportion.*

772. *Why does the working of the wheel plough generally require a smaller expenditure of force than that of the swing plough?*

It is principally, if not fully, explained by the *more uniform horizontal motion* communicated to the share and sole of the former, through *the regulating medium of the wheels*, at the forepart of the beam, which *diminish the shocks arising from the continual vibrations of the implement, when balanced between the hand of the ploughman and the back and shoulders of the horse.*

773. It is not intended that wheels so situated act the part of *lessening the friction between the sole and the soil;* but they keep the rubbing part *more truly to its depth,* and *maintain its horizontal action more correctly;* whereas the horses affect a swing plough *at every step by the irregularity of their proper movement,* which has to be *counteracted by the effort of the man at the opposite end.* Thus, conflicting forces are momentarily produced, and continual elevations and depressions of the point of the share take place, together with deviations from the flat position of the sole, which should be at right angles to the perpendicular; and to remedy which, unskilful ploughmen bear unequally on the stilts, which produces a lateral pressure landwards, and, consequently, a great amount of friction along the whole of the left-side place of the plough. *However small may be the efforts of the ploughman to keep his plough "swimming fair," those efforts must*

* Dickson.

"Spring's early hopes seem half-resigned,
And silent for a while remain;
Till sunbeams broken clouds can find,
And brighten all to life again."—CLARE.

*be attended with increased resistance, and, consequently, with increased exertion to the horses.**

774. *The best form of a plough* cannot be determined *without regard to the soil in which it is designed to work.* The test of perfection in the work of a plough is, that the furrow-slice shall lie, after being turned over, in a perfectly straight line, not only unbroken, but even uncracked. It is by patient attention to this point that Mr. Busby, with the aid of an excellent farmer, Mr. Outhwaite, produced the beautiful mould-boards of his prize ploughs. This unbroken furrow-slice requires some length of mould-board; and it is urged, on the other hand, in behalf of *short mould-boards,* that *they pulverise the soil while they turn it over.* Practical farmers, however, know that to *pulverise* is *not the immediate object of ploughing land;* but as the length of the English mould-boards surprised foreigners, it may not be useless to state a further reason for that apparently excessive length. English mould-boards were, in fact, made short and hollow, until at one of the Royal Agricultural Society's trials, all the selected ploughs were *brought to a stand in attempting to work a strong clay.* The cause of the failure was this: the chief resistance to the horses in ploughing proceeds *not from the weight of earth moved,* which is insignificant, nor, unless the ground be unusually baked, *from the act of severing the earth,* but from two other causes, namely, FRICTION, and, on certain soils, still more from COHESION. Now, if the soil contain *sharp sand,* there will be *no cohesion;* it will *work freely off the mould-board,* which will be kept bright, and the shorter its surface the less will the friction be. For *such soils,* therefore, as are common in Scotland, *short mould-boards may be the best.* But most English soils contain so much clay as will *adhere to and fill up the hollow of a short mould-board,* so that the furrow slice will have to work, *not upon an iron surface,* but upon the most disadvantageous of all surfaces, *one of rough loam,* and the draught may thus be easily *doubled by friction and cohesion together.* Hence, English mould-boards have been very properly lengthened, the more properly because the same soil will more often have to be worked in a moist state here than in continental Europe. Many of the foreign ploughs, it should be said, behaved, under all disadvantages, exceedingly well, and were, no doubt, well suited for their respective localities.†

* Mr. Handley, M.P. † "Reports of Exhibition Juries, 1851."

"Some far from the market, delight not in pease,
For that every chapman they seem not to please;
If vent of the market-place, serve thee not well,
Set hogs up a-fattening, to drover to sell."—TUSSER.

775. *Why should land not be ploughed in a state of wetness?*

Because tenacious lands, when subjected to the operation of ploughing *in such a condition*, are apt to *run together in lumps*, which it is afterwards *extremely difficult to reduce*, besides being greatly *injured by the treading of cattle*, whose feet make *holes which become filled with putrid water*. This observation applies *chiefly* to *marshy fields*, which have been recently brought into cultivation, and which, above all others, ought not to be endangered by *unseasonable tillage*; but no land, *whatever may be its qualities*, should be *ploughed in a wet state*.*

776. *Why should the direction of the ridges be north and south?*

This arrangement is recommended by experienced farmers, so far as the situation of the field will admit of it. Deviations from this rule, for the purpose of drainage, or on account of the particular form of an enclosure, may be sometimes necessary; but it seems always advantageous to *bring the course of the ridges as near as possible to the line mentioned*; for it appears that in those which have an *east* and *westerly* direction, even when the elevation is not considerable, the crop on the *south side* has ripened a *week earlier* than that on the *north*.* In the north and south direction, the east and west sides of the ridges *divide the sun equally between them*, and their produce *ripens at the same time*.

777. *Why is autumnal ploughing most beneficial to adhesive soils?*

Because *frost*, acting on the *moisture* which they contain,

* Encyclopædia Metropolitana.

778. *Why are frequent ploughings necessary?*

For the purpose of preventing the natural *separation of soils and manures.* Ploughing should be conducted with careful regard to the following principles:—

779.—1st. An additional depth should first be gained in autumn, *that a successive change of seasons may take effect in atmospheric influences,* before any seed is ventured in the raw stratum brought up.

780.—2nd. The quality of that stratum should be examined; it is sometimes sterile by reason of an acid, discoverable by boiling in water, and putting that water to the test of blue infusions.

781.—3rd. *Animal and vegetable matters cannot be buried:* at whatever depth they are deposited, *their constant tendency is to rise to the atmosphere.*

782.—4th. *Fossil manures are extremely liable to be buried,* having a *constant tendency downwards. Chalk, marl,* and *clay,* are sufficiently soluble, or so miscible with water as to *mix in a regular mass,* and are sometimes found *much below the path of the plough.*

783.—5th. In soils of a poor hungry quality, there should be some proportion observed between the *depth of ploughing,* and the *quantity of manure usually spread;* but this does not hold good upon better soils.

784.—6th. Soils are rarely found that *ought not to be ploughed in common,* SIX *inches deep; many ought to be stirred* EIGHT *inches, and some* TEN.

785.—7th. One *deep ploughing,* to the full depth, should be given *once* in *twelve, eighteen,* or *twenty-four months;* if this be secured, *shallow tillage,* by *scaling, scarifying, scuffling, shimming,* or *broad sharing,* is *in many cases preferable to deep working oftener, and especially for wheat, which loves a firm bottom.**

* Encyclopædia Metropolitana.

† "Annals of Agriculture."

"The land, allowed its losses to repair,
Refreshed, and full in strength, delights to wear
A second youth, and to the farmer's eyes,
Bids richer crops and double harvests rise."—CHURCHILL.

786. *Humus*, in the state in which it is usually found in the earth, is not soluble in water, and we might have some difficulty in comprehending how it enters into the minute vessels of the roots of plants; but here the admirable provision of nature may be observed. Humus is *insoluble* and *antiseptic; it resists further decomposition in itself*, and in other substances in contact with it. It remains for a long time in the earth unimpaired; *but no sooner is it brought into contact with the atmosphere, by the process of cultivation, than an* ACTION *begins.* Part of its *carbon* uniting with the *oxygen* of the *atmosphere*, produces *carbonic acid*, which the green parts of plants readily absorb, while its *hydrogen* with the same forms *water*, without which plants cannot live; and, in very warm climates, where this process goes on more rapidly, the moisture thus produced keeps up vegetable life, when rains and dews fail. The residue becomes a *soluble extract*, and in that state *is taken up readily by the fibres of the roots.* But the changes still go on, the extract absorbs *more oxygen*, and becomes *once more insoluble*, in the form of a film, which Fourcroy calls *vegetable albumen*, and which contains a small portion of *nitrogen. By bringing fresh portions of humus to the surface* and permitting the *access of air* to it, *more carbonic acid, water, extract*, and *albumen* are formed, and *give a regular supply to the plants*, which, by their living powers, produce the various substances found in the vegetable kingdom of nature. *Hence we see the great importance of frequently stirring the surface of the earth between cabbages and other vegetables.**

787. *Why should the autumn ploughing of stubbles be conducted with the greatest possible care?*

Because the ploughing of stubbles for the fallow-crop is THE MOST IMPORTANT OPERATION *of the whole rotation, and the succeeding crops will greatly depend upon the way in which it is done.* Many farmers conduct their stubble ploughing in a slovenly manner, "because it is ONLY the stubbles." But it is MORE than the stubbles—

* Penny Cyclopædia.

'Where barley ye sow, after rye or else wheat,
If land be unlusty, the crop is not great:
So lose ye your cost, to your corsie and smart,
And land (overburdened) is clean out of heart."—TUSSER.

IT IS THE AMELIORATION OF THE SOIL FOR THE SUCCEEDING CROPS.

788. We should aim at *quality* rather than *quantity*, ploughing as deep as the soil will allow, without bringing up above an inch or two of the subsoil; holding small furrows, and laying them up at a considerable angle, so that the rain will not remain long on the surface; laying out the field into convenient sized lands, higher or lower, larger or smaller, according to the tenacity of the soil; carefully curving out the furrows, and making proper grips to carry off the excess of water consequent upon heavy winter rains.

789. By such means, *we ensure the soil receiving all the benefits which the changes of weather can produce:* the atmosphere will penetrate, *because we have taken precautions to allow of the moisture getting away;* the soil must become *pulverized*, and will be ready to work in the spring much sooner than land untouched, which, lying flatter, with no surface drainage, will most likely have remained saturated with moisture all winter, and will turn up raw and stubborn, *at the very time that the autumn ploughed may be ready to receive a crop.**

790. The object of *ploughing in autumn* is to *smother the surface-weeds*, which would grow in mild weather, *even in winter*, by inverting the surface of the ground, and to *expose the earth under the root-weeds to the frost*, by turning up the bottom of the furrow-slice to the air. It is clear, that the more closely the inverted surface can be placed, and the more exposed the under part of the furrow-slice can be exhibited to the influence of frost, *the better is the chance* of smothering the surface-weeds, and of *killing the roots of the root-weeds.* The advantages of ploughing may be obtained, in the greatest degree, by *placing the furrow-slice at an angle of 45° with the horizon;* and yet a practice prevails in many places, which decidedly runs counter with this principle, and that is,—of laying a loosened furrow *right on its back over the surface of a rib of land which is left untouched by the plough.* The appearance of this kind of work is that of very ill-made drills.†

* J. Coleman.

† "Quarterly Journal of Agriculture."

"O, Rural Life! what charms thy meanness hide;
What sweet descriptions bards disdain to sing,
What loves, what graces on thy plains abide."—CLARE.

791. *Why is "ridging" best for some lands, and for others "flat-work?"*

Because, when land is *naturally dry*, or has been *made so by drainage*, the *flatter* its surface is kept, the *better for the plants* which grow upon it. But, in a *moist climate*, with an *impervious soil*, the ridging of the surface causes rain-water to *pass off more rapidly*, and keep the soil drier than would be the case if it were *kept flat.*

792. We are not forgetful that there are clays so impervious that, probably, no amount of draining or disintegration of the subsoil will render it safe to dispense with ridging. There are, however, exceptional cases, and, as a rule, such a condition of soil and subsoil should be aimed at as will admit of the expedient of ridging being altogether dispensed with. *Unless land can absorb the whole rain which falls upon it, its full range of fertility cannot be developed;* FOR *the same showers which aggravate the coldness and sterility of impervious soils, carry down with them, and impart to those which are pervious, ever fresh supplies of genial influences.* Instead, then, of *this perennial source of fertility being encouraged to run off by surface channels, or to stagnate in the soil and become its bane,* let PROVISION BE MADE FOR ITS FREE PERCOLATION THROUGH AN OPEN STRATUM SEVERAL FEET IN THICKNESS, *and then for its escape by drains of such depth and frequency as each particular case requires.* When this is attained, a flat surface will generally be preserved, as alike *conducive to the welfare of the crops,* and to the *successful use of machinery* for sowing, weeding, and reaping them.*

793. *Why should care be taken not to make the ridges too high?*

Because high ridges labour under *several disadvantages* The soil is *heaped* upon the crown, leaving the furrows *bare;* the crown is *too* dry, the furrows too wet; the *crop,* which is always *best* upon the *crown,* is more readily *shaken*

* Encyclopædia Britannica.

"Ere the dawn
Had broke upon the upland-lawn,
He hied him to his daily toil,
To turn the glebe, or mend the soil."—CAWTHORN.

with the wind, and *laid;* the half of the ridge is for many hours *shaded from the sun;* they also sink the furrows below the *level of the ground*, and *retain water at the end of every ridge.**

794. *Why should the number of horses to a plough be reduced to the smallest number that can be worked to advantage?*

Because in tenacious soils the *injury done by the treading of horses' feet is considerable. A small number of well-kept horses give a better return for their cost than a larger number of ill-fed and weakly animals.* The necessity for a large number of horses is generally the result of *the weight and cumbersomeness of the plough*, which becomes *a permanent tax upon the farmer.*

795. People accustomed to the use of two horses in a plough, know that they are fully *adequate to the tillage of any soil*, even of the heaviest sort, and are, besides, more expeditious. This has long been known, and is further strengthened by important *improvements* upon the two-horse plough, since its introduction. Assuming that the number of horses employed in British agriculture in England and Wales, amounts to 762,304, *there is employed one-third more horses than are necessary to the proper cultivation of the soil in those countries*; hence there are 254,100 supernumerary and useless horses *usurping the place, and consuming the food of man.* Now, a pair of horses and a driver cannot be kept for less than £80 (or $400) a-year, on the most moderate calculation; and 127,050 pairs, with a driver for each pair, occasion a yearly loss of £10,164,000 (or $500,320,000).†

* Burrowe's Encyclopædia.
† Mr. Laidlaw, "On the Adoption of Two-horse Ploughs."

> "Where water all winter annoyeth too much,
> Bestow not thy wheat upon land that is such;
> But rather sow oats, or else bullimong there,
> Grey peason, or runcivals, fitches, or tare."—TUSSER.

796. It is proper to state the reasons which farmers of Oxfordshire give for using *five horses* in a plough during the winter season. First, they allege the stiffness of the clay, and the consequent heavy drought; second, that they find *the horses stand the work much longer* when not too hard pressed; third, that part of the team consists of *young horses*, which are thus *exercised*, and assist in the labour, without injury to themselves; and, as to their being yoked in a line ahead of each other, instead of two abreast, it is so arranged to prevent the injury which would otherwise be done to the soft surface-soil by the feet of the "land"-horse.

797. In wet undrained land, the injury done in this way would, no doubt, be very considerable; and even when this heavy land is drained, the trampling of horses is hurtful in wet weather. But, if we suppose a person, who was entirely ignorant of the operation of ploughing and its effects, looking at these five large horses as they follow each other in a straight line in the bottom of the newly-turned furrow, and carefully watching the close succession *in which their twenty heavy iron-shod feet beat into the waxy subsoil*, he would conclude that *the operation intended was to render that subsoil impervious*, and that the turning over of the furrow was merely a subsidiary process. And when one considers that the bottom of every furrow in the field is *subjected to the same repeated pressure*, he sees at once *the reason for this soil being easily wet in winter*, and *suffering readily from drought in summer*. If the soil is really of such a character that *five horses* are *necessary* to plough it, and if, to save the surface, it is requisite to sacrifice the subsoil, it becomes a question whether the SPADE and *manual labour* would not be found at once *cheaper*, and infinitely *more effectual*.*

798. *Why, in ploughing, in manure, derived from sheep-folding, should the ploughing be shallow?*

Because otherwise the sheep manure, which consists of small and finely-divided fragments, will be carried deep into the soil, and the succeeding rains will wash the fertilizing products to a depth beyond the reach of the plants.†

* Caird's "English Agriculture." † Dr. Spregnel.

> "The husbandman, to spare a thankful soil,
> Which rich in disposition, pays his toil
> More than a hundred-fold, which swells his store
> E'en to his wish, and makes his barns run o'er."—CHURCHILL.

799. *Why is "ploughing in," more profitable than "feeding off."*

Because vegetables, when *ploughed into the soil*, decompose, and yield just the same elements of manure, as they would do, if digested by animals. *An animal imparts no peculiar or essential property to manure by the digestion of its food*, and while an animal feeds, there is a certain *expenditure* or *waste* constantly going on, to support the vital functions of the creature's system.

800. Take the case of a crop of *turnips*. Suppose you have two pieces of land, each producing twenty tons per acre, and in the one instance you chop up the turnips, and spread them on the land, and in the other feed off with sheep, and then plough the whole in, and sow a barley crop. I maintain that you would have a much larger crop of barley where you did not fed the sheep than where you did; that where the turnips were, by themselves, cut up and ploughed into the land, you would have much more nutriment adapted for the succeeding plant, than where you feed the sheep upon it. Whence can a sheep derive manure except from its food? It has no power of deriving it from any other source, because the animal is only a *consumer*—it *does not* impart anything. Therefore, feeding is only a waste, *unless* you realize a benefit in regard to your stock.*

801. Mr. Nesbit from whom the proceeding remarks have been quoted, applied to a number of his friends to try some experiments upon the relative advantages of "ploughing in," and "feeding off." The following is one of several letters confirming his opinion:—

"*Naseby, May* 15*th*, 1849.

"In the spring of 1846 I had more turnips than my stock could consume; I thought that it was reasonable that, if the crop was broken to pieces and ploughed in, the grain crop that followed would derive as much benefit as if eaten by sheep. I therefore did so with one acre, in the first week in February, and with another upon the fourth

* Nesbit's Lectures.

"There's not a rood of land demands our toil,
There's not a foot of ground we daily tread,
But gains increase from Time's devouring spoil,
But holds some fragment of the human dead."—CLARE.

week in March. Part of the rest of the field was eaten on the land, and part being newly ploughed-up land, the whole crop was drawn off. On the land where the turnips (white rounds) were broken and ploughed in on the last week in February, the produce was *eighty-four bushels per acre of Hopetown oats.* When the turnips were broken and ploughed in on the fourth week in March, the produce was *seventy-four and a half bushels per acre;* where eaten on the land by sheep, *seventy and a quarter bushels per acre;* and on the newly ploughed-up land, the whole of the crop drawn off, *forty-one bushels of wheat.*"*

"JOHN OAKLEY.

"J. C. Nesbit, Esq."

802. *Why is it desirable in certain lands, to scarify the stubble immediately after the corn crop?*

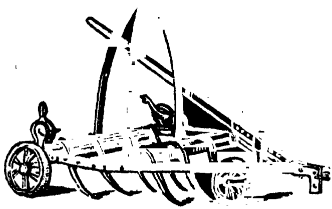
The theory on which this early culture is recommended is, that *twitch,* immediately after harvest, is comparatively weak, and has not extended its roots far beneath the surface; but, *as soon as the corn crop is removed,* and the twitch PERMITTED TO GROW WITHOUT OBSTRUCTION, *it spreads* RAPIDLY *along the surface, and penetrates deeply beneath it;* and every week that it is left undisturbed, renders its extirpation *more difficult and expensive. Tear it up early, and the seedlings are at once shaken out entire from the tender soil;* leave it to *strike a deeper root,* and every broken fibre that remains *strikes afresh,* and, gaining strength throughout the winter and early spring, *gives the farmer at that busy season the expense of a second fallowing.*†

803. The *cultivator or scarifier* is a machine adapted for *stirring and mixing the earth,* without the *repeated use of the plough;* and also for loosening and *separating roots and weeds.* The scarifier has a number of shares and tines which enter but a few inches into the

* Nesbit's "Lectures on Agricultural Chemistry." † Caird's Agriculture.

"All manner of straw that is scattered in yard,
Good husbandly husbands have daily regard;
In pit, full of water, the same to bestow,
Where lying to rot, thereof profit may grow."—TUSSER.

ground and *divide the soil*, but do not *turn it over*. The *harrow* operates in a similar manner. When the land is very foul, and calculated to choke the teeth of the harrow, a powerful and effective instrument is generally used, known as *Finlayson's harrow*, as represented in the annexed engraving. This instrument possesses the following advantages:—From the position



in which the tines are fixed, their points hanging nearly on a parallel with the surface of the land, the instrument is drawn with the least possible waste of power. From the curved form of the tines, all stubble, couch, &c., is brought up to the surface, and rolled over them—the instrument thus relieving itself in its progress. The readiness with which the cultivator can be adjusted, so as to work to any depth, renders it of great value, inasmuch as the regulator or lever can be moved up and down with the greatest ease, each notch upwards giving the tines an additional depth of one and a half or two inches. The axletree of the wheels is also capable of being moved up and down by a screw, so that the whole implement can be easily adjusted to work at any depth, from four to ten inches. In turning at the headlands the lever is pressed down to the lowest notch, thereby elevating the front tines out of the soil, and allowing the instrument to be easily moved round. *Armstrong's harrow* differs from others in the form of its framing, which is of iron and of a zig-zag shape, so arranged that the tooth or tine shall be fixed at each angle, in such manner that the lines formed by them shall be equidistant over the breadth of the land they are intended to cover. They can be adapted either for heavy or light work. *Morton's revolving brake harrow* proves an effective implement on light sandy soils. The principle is somewhat similar to that of the hay-making machine, except that, in place of the surface, it goes to the very bottom of the furrows, bringing up a far greater quantity of weeds than any fixed harrow could be expected to accomplish. *Biddell's extripating harrow* is intended for breaking up land when it is too hard for the heaviest harrows, and for bringing winter fallows into a fine state of tillage. In working summer lands, by the shape of its teeth it is calculated to bring to the surface all grass

'See! in yon valley, while the mellowing grain
Embrowns the slope, and nods along the plain,
A crowd of rustics doomed to daily toil,
Disarm the forest, or enrich the soil."—CAWTHORN.

and rubbish; it is also found generally useful for accomplishing fine tillage. *The Norwegian harrow* is to be met with in two or three varieties. It is most valuable immediately after ploughing; it breaks and pulverizes the land, leaving three or four inches' depth of fine mould, well prepared for seed; it saves the use of the heavy and middle-sized ordinary harrows, the small seed harrows, once after sowing being sufficient

804. *Why is "clean farming" the very foundation of good farming?*

Because the *weeds* of nature are ever STRUGGLING FOR EXISTENCE with the *cultivated plants.* The labour and supervision of man keep down the wild plants while the cultivated crops are growing; but *immediately that the cultivated crops are removed,* the wild plants SPREAD WITH IMMENSELY AUGMENTED ENERGY, *and strive to obtain ascendancy over the soil.*

805. The manner in which vegetables struggle for occupation of the soil may be broadly illustrated by an example of what De Candolle terms "the right of prior occupation," which explains how it happens that *forests and prairies are found naturally to exclude each other.* If, by any cause, a forest is established in a given place, the *shade of trees,* together with the greediness with which the roots absorb the nutriment, and the manner in which the fibres of the latter are interlaced, will *prevent the grasses from shooting up underneath.* If, on the contrary, the prairie is *first developed,* then, even supposing that the seeds of the trees do from time to time germinate, yet *their roots in the young state cannot easily pierce the close network of roots and stems already existing on the spot;* and if they succeed in doing so, are *starved by the voracity of the grass roots,* which are more numerous and more developed than their own.*

806. *Weeds are the insidious enemies of agriculture,* and it is to their subtile growth that we ascribe much of the inattention to their

* De Candolle's "Vegetable Organography."—See also "The Botanical and Horticultural Reason Why."

"Once more the rising source of day,
Pours on the earth his genial ray;
Withdraws the starry veil of night,
And smiles on every mountain height."—HOPKINSON.

extermination. That *slovenliness is too often the rule,* is attested by the state of many farms. For want of the expenditure of a sixpence, whole acres are over-run and rendered redeemable only by an outlay of many pounds. *Manure is lavished;* whereas, *by an unremitting attention to the autumn stubbles,* the task of keeping a clean soil is comparatively easy, and the gain will be made apparent by the ameliorated condition of the soil, whereby *it requires less cultivation, and yields greater crops, of superior quality.**

807. *What should be done with the vegetable matter of the weeds?*

There are *three methods* pursued, after the soil has been pared, and the rubbish dragged into rows. 1. To *burn the heaps* and *spread the ashes.* 2. To *mix lime* with the vegetable matter, when carted to some convenient spot. 3. To *cart it to the homestead,* where it serves to *form the bottoms of the cattle yards.*

808. *With regard to the first plan*—fine weather is indispensable to its practicability; but, when this prevails, *it is the best and cheapest means of destroying all weeds,* and therefore the one to be adopted, *when the soil is not liable to be injured by the addition of ashes as a manure.*

809. *With regard to the second,* in the event of rain, the application of *lime* will be the most efficient means of destroying the vegetable matter, and *converting it into a valuable manure.*

810. *With regard to the third,* the *expense* of *carting backwards and forwards* is a great objection. Some farmers send men into the stubbles with a fork to dig out the patches of couch, which they throw into a cart, lay in a long heap in the field, then cart on dung, and

* E. E. Agate, "Prize Essay."

"Where peason ye had, and a fallow thereon,
Sow wheat ye may well, without dung thereupon;
New broken-up land, or with water opprest,
Or overmuch dunged, for wheat is not best."—Tusser.

the whole being turned, it is *applied to the next crop.* This is an expeditious way, *but the treading is detrimental to the land*, and the operation could be *performed better by the scarifier.**

811. *Why should sandy and light soils* especially *be prepared in autumn, for the turnip crop?*

Because *moisture* acts an important part in the growth of *root crops*, and without a large amount roots cannot succeed. *Sandy, peaty,* and *limestone* soils, *all have a tendency to lose moisture quickly after receiving it.* There is much *more opportunity* for cleaning light friable soils in autumn, than those of a more adhesive nature. It is well, therefore, to *clean all the foul light land in autumn,* whenever the season will permit. For this *particular* reason: that when the cleaning has to be done *in summer,* the land usually becomes so dry in the course of working, as to be unsuitable for getting a *turnip braird* without a heavy *accidental fall of rain.* Therefore *all soils which have a tendency to lose moisture quickly, should be prepared for the turnip crop in autumn.* When the season does not permit of autumn cleaning, the chance of growing a turnip crop successfully on light lands, rests upon early working in spring.

812. From trials, I have found that a dry *loamy soil* will imbibe 50 *per cent. of water* without dropping; a *sandy soil* little more than *half as much.* Loam and peat have, from the nature of their particles, great power of imbibing moisture. *Sand* has comparatively little *attraction* for water; and the clear glass-like fragments of which it is composed cannot absorb water: it runs through between them; and in summer, rain either *sinks suddenly down,* or *evaporates quickly from the surface.* It is for such reasons that light soils so soon lose moisture, and require peculiar management.†

* E. E. Agate. † R. Vallentine, Burcott Farm, Leighton Buzzard.

"O Spring, thou fairest season of the year,
How lovely soft, how sweet dost thou appear!
What pleasing landscapes meet the gazing eye,
How beauteous nature does with nature vie."—WEBB.

813. *Why is there much ground for doubting that the system of "naked fallowing" is attended with the degree of good attributed to it?*

Because, according to the theory already explained, by the action of the *vegetable matter* on the *oxygen* of the atmosphere, *carbonic acid gas* is formed; but *the greater part of it is dissipated and lost to the farmer.* The rapidity of the decomposition of soluble substances contained in the soil is greatly promoted, and the volatile fluids are *exhaled*, by the influence of the sun; but *at the very time when a large quantity of nutritious matter is produced*, THERE ARE NO USEFUL PLANTS TO DERIVE ANY BENEFIT FROM IT.*

814. *Fallowing, under the old system, is always to be regretted*, because the process *entails expense* without *immediate profit.* It was this circumstance, in all probability, which first suggested the idea of raising an *intermediate crop* on the naked fallow. It was felt that *any plant which would arrive at a useful degree of perfection in the space of four months*, would be of *great importance to the live-stock farmer*, and at the same time *prevent the naked soil from being parched and impoverished by the heat of the midsummer sun.* The *clovers*, and their alliances were recommended, as well as the several *grasses;* but the TURNIP was *found the most eligible*, whether to be eaten or drawn off before wheat sowing, or to stand over the winter, to be eaten off in the spring. *The introduction of the turnip upon the fallows formed quite an era in British farming.* It introduced the *four-course rotation of cropping* over all the lighter descriptions of land,*—a system which was not perfect, but was afterwards followed by *five and six courses*, and by *variations of courses*, with wonderful advantage.†

815. *What is the great general principle to be borne in mind in the application of manures?*

It is this—that manures may be divided into THREE

* Encyclopædia Metropolitana. † Quarterly Journal of Agriculture.

> "Oats, rie, or else barley, and wheat that is gray,
> Bring land out of comfort and soon to decay;
> One after another, no comfort between,
> Is crop upon crop as will quickly be seen."—TUSSER.

CLASSES: 1. *Those which give nitrogen to plants.* 2. *Those which restore to the soil the mineral nourishment withdrawn from it by plants;* and, the MOST IMPORTANT—3. *Those which perform* BOTH *offices*—a class to which *urine* belongs.*

816. Amongst the manures which are comparatively new to agriculture, the following may be mentioned, with their specific adaptations:—1. *Phosphate of lime*, or *bone-dust*, so useful in *turnip, potatoe*, and *grass* land. 2. *Guano*, having *very general* fertilizing properties. 3. *Rape-dust*, which answers admirably for *turnips*, is noxious to the *wire-worm*, and produces good *wheat*. 4. The *nitrates* of *potass and soda*, which are said to increase our crops of *wheat* and other *cereal grasses* in a remarkable manner. 5. *Kelp*, which has also been employed with success for *corn crops*. 6. *Common salt*, which is considered beneficial to the same light soils; and 7. *Gypsum*, which is efficacious in *leguminous crops*, and probably to others.†

817. *Why should the production of meat upon a farm bear a definite relation to the amount of grain exported?*

Because grain crops can be grown *at a cheaper rate* BY THE PRODUCTION OF MEAT, *than by the direct action of* ARTIFICIAL MANURES; the propriety of adopting the former course to its full extent becomes, however, a *question of capital*. It would require *five times as much capital to produce the same amount of corn by means of stock as could be produced by artificial manures*. It is the same with the manufacturer who employs the *high-pressure* or a *double-cylinder* engine; with the former his capital

* Dr. Fownes. † Dr. Daubeny.

"The lights of Heaven (which are the world's fair eyes)
Look down into the world, the world to see;
And as they turn, or wander in the skies,
Survey all things, that on this centre be."—DAVIES.

invested is SMALL, *but the interest paid upon it by the daily consumption of fuel is very great,* while with the latter his invested capital is GREAT, *and his daily interest comparatively small.**

818. In feeding stock, but a small proportion of the *nitrogen* in the food is *converted into the substance of the animal;* the greater portion is *returned to the soil as manure.* The economy of the production of meat, as a means of obtaining manure, arises from the greatly increased value of the nitrogen in flesh, as compared with that supplied in the food. Thus 28lbs. of *flesh* worth 14s., contains 1lb. of nitrogen; 28lbs. of *peas, beans,* or *oil-cake,* which contain about the same quantity, are not worth more than 2s. or 3s.*

819. When turnips are plentiful, and stock is dear, farmers not unfrequently *give their turnips to any person who will bring stock to consume them.* And it is a common practice in some places to feed a quantity of half-starved cattle upon *straw,* for the *purpose of converting it into dung.* It should, however, be understood that *the passage of the straw or turnip through the stomach of the animal, far from adding to the quality of the substance as manure, abstracts a large proportion of their valuable elements.* There is no magical property in the black mass called "*dung,*" which *did not exist* in the *straw.* Some of the elements may be rendered *more rapidly available,* BUT *the actual quantity restored to the soil must be considerably reduced.**

● 820. In the "*Gardener's Chronicle,*" for the year 1844, are given the results of some experiments upon *feeding sheep,* conducted upon the farm of the Earl of Ducie, by Mr. Morton; some of these sheep were fed *in the field,* some *under cover.* Altogether, 25 sheep were experimented upon, and they increased 611lbs., having consumed 31,580lbs. of swedes, 2,775lbs. of oats. Calculating the food to have contained 95lbs. of *nitrogen,* and the increase of live weight, to represent 21lbs. of *nitrogen,* the *one pound of nitrogen produced six and a half pounds of live weight, and for each pound of nitrogen exported in meat, three and a half remain for manure.**

* Mr. J B. Lawes.

"Thou eye of Nature! whose extensive ray
With endless charms adorns the face of day;
Consenting raise the harmonious joyful sound,
And bear his praises through the vast profound."—BOYSE.

821. In my experiments upon wheat, it required *five pounds of ammonia to produce a bushel of corn.* To obtain this amount of ammonia *by means of stock,* there should be *an increase in the weight of one thousand pounds.* In order to bring an exhausted soil to the highest state of fertility, it will be necessary to produce an amount of meat, by means of *imported* food, (such as *hay* and *oil-cake,*) *equivalent to the increase of grain required.* As the green crops increase year by year, the same amount of meat will be produced, but the importation of artificial food will gradually decrease to the point *at which the internal and external resources of the farm are so balanced as to secure the largest amount of produce the soil.**

822. A most important consideration is THE QUANTITY OF MEAT MADE ON A FARM PER ACRE, for, in proportion to this, will be THE QUANTITY OF CORN GROWN.

823. By asking a few questions of a farmer I can almost immediately arrive at a conclusion as to his position, without visiting his farm. The first question would be "How much meat do you make per acre, over the whole acreage of your farm?" This question has been solved by Mr. Thomas Dyke Acland, in the Royal Agricultural Society's Journal, Vol. xi., page 666. There it will be seen that the largest corn-growing farmer in Norfolk, a most successful man, produces 4½ *score of meat* on *every acre* of his land. Compare this with the general average of farms in the kingdom, which certainly do not produce one score pounds of meat per acre. *The more meat you make, the more manure you produce, and the more corn you grow.* The common labourer is the best evidence on this point; with his one-eighth of an acre of ground he knows that unless he keeps a pig to make manure, he cannot expect a crop. Therefore he fats one pig, which consumes three sacks, or 12 bushels of barley-meal, which, at 7lbs. of meal to 1lb. of meat, would be 84lbs. of meat, or four score on the one eighth of an acre, or over 32 score per acre.

824. It has often been remarked that, amidst miserable land and wretched farming, *the labourer's cottage-garden is like an oasis in the desert;* but when I show that independent of deeper cultivation, *it receives in manure* 32 *times the farmer's quantity,* the contrast

* Mr. J. B. Lawes.—Journal of the Royal Agricultural Society.

"Two crops of a fallow enricheth the plough,
Though t' one be of pease, it is land good enough;
One crop and a fallow, some soil will abide,
Where, if ye go further, lay profit aside."—TUSSER.

need no longer be a matter of surprise. Of course the farmer who makes the largest quantity of meat obtains a proportionate amount of manure, and of produce.

825. Some years ago, when good Danish barley could be had for 19s. per quarter, I fattened an immense quantity of pork, and other meat, equal to at least 20 score per acre. *The farm has never forgotten it,* and *as I made so much manure when corn was cheap,* I have been *enabled to grow large crops during the late high prices;* thus justifying the calculations I made in my celebrated balance-sheet. I seldom make less than 10 to 13 score pounds of meat per acre *over the whole farm;* IT IS THE KEY TO GOOD CROPS.

826. *Assuming that 7lbs. of beans or oil-cake will make 1lb. of mutton,* IT WOULD PAY A FARMER WELL TO SELL HIS BEANS TO HIS SHEEP at 40s. PER QUARTER, because that price is about one penny per pound, and mutton at seven pence per pound would pay for seven pounds of beans. The beans thus remain on the farm; but, even supposing that you give to your sheep four quarters of beans per acre, and that you lose 10 per cent. by them, or 16s. per acre, I am prepared to prove that *in the corn crop that follows,* the increase will be at least £3 per acre beyond the sum that would otherwise be realized.

827. I know a farmer, within a few miles of me, who always allows his 1,500 fattening sheep 1lb. of beans per diem when feeding in the field; the consequence is *a general and progressive enrichment of the soil,* which almost compels him to take an extra corn crop to *tame* the land. In my own case I generally on one field, annually, which has become saucy, take five or six quarters of rivet wheat per acre after a similar crop of ordinary wheat. The farmer to whom I allude, takes green rye after oats, rye fed off with sheep eating beans, then turnips, put into little mounds, and fed off in February and March with sheep eating beans, then barley with seed, then clover once mowed, and then fed off with sheep eating beans, then wheat followed by oats, which completes the rotation—thus growing three corn crops, one root crop, and two green crops in a course of five years, with an increasing fertility. The fact is, the poverty-stricken principle of a lot of hungry, half-starved sheep *growing into money,* and *exhausting the land,* is a miserable and ruinous plan, and the time

will come when our agricultural friends will fat more at home, rather than supply us with the heart of their land in the shape of lean stock.*

828. *Why, in fold-manuring, if the soil be hard or stiff, should it be loosened before turning on the sheep?*

Because the soil is then enabled both to *absorb the perspired gases of the sheep*, and also to allow the *fluid excrements*, which are the first to undergo decomposition, *a free passage into its pores.**

829. *Why should the droppings be ploughed or harrowed in, as soon as the sheep are removed?*

Because this *prevents the evaporation* of valuable constituents of the manure. It must be ploughed in *shallow*, however; otherwise, when the manure is deep in the soil, the rain which follows will carry the manuring matter beyond the reach of the roots. *Harrowing-in* will, on light soils, be sufficient. It is also essential that a *good distribution* of the fold-manure over the field should be effected; and in order to accomplish this, the sheep should be brought into a *moderate space*, as they are generally in the habit of herding thickly together, and of lying in one or other particular corner of the enclosure, and *manuring such parts disproportionately with the rest:* hence, when the space enclosed is *too large*, many parts of the field obtain no manure whatever; on the other hand, the enclosure ought not to be *too small*, as it would then be *injurious to the sheep*, from the inconvenience it would cause them in lying down.†

* Mechi's "How to Farm Profitably." † Professor Spregnel.

"Some countries are pinched of meadow for hay,
Yet ease it with fitches, as well as they may;
Which inned and threshed, and husbandly dight,
Keeps labouring cattle in very good plight."—TUSSER.

830. *Why does the "fresh" urine of folded sheep do no injury to vegetation, while "fresh" urine, if otherwise applied, is found to be caustic and prejudicial?*

Because the young crops, even with the strongest fold-manuring, receive only a *very small quantity of manure.* Growing plants suffer no injury from fresh manure in folding, because they are *able to digest sufficiently the small quantity which they absorb.* Besides, the soil in general contains sufficient *humic acid* to *neutralize* at once the *ammonia* developed from the droppings.

831. *Why is fold-manuring preferable to collecting sheep dung in the shed?*

The advantages of fold manuring are held to be:—

832.—1. The *conveyance* of the manure is saved: a circumstance of no inconsiderable account, where the fields lie at a distance, and the roads are bad.

833.—2. By fold-manuring, we can render *immediate aid to a weak and sickly crop,* and even *spring barley* may be brought by its means to luxuriant growth.

834.—3. Winter corn, also, where the soil is not wet and clayey, may be fold-manured *even when considerably grown,* and thus there is no necessity for allowing the seed-time to pass away while dung is being carted out.

835.—4. By means of fold-manuring, loose, sandy, and moorland soils are not only *dunged,* but become *more firm and compressed* by the treading and lying of the sheep.

836.—5. *Field mice are driven away,* and the *slugs are destroyed.*

837.—6. The crops which are grown after fold-manuring are *clearer of weeds* than those after ordinary manure, which brings many seeds of weeds upon the land.

> "Look well to thy horses in stable thou must,
> That hay be not foisty, nor chaff full of dust;
> Nor stone in their provender, feather, nor clots,
> Nor feed with green peason, for breeding of bots."—TUSSER.

838.—7. The sheep, in hot weather, are always *more healthy* from being in the hurdles at night than in the houses; but in cold and rainy weather, it will be more advisable, especially in the case of fine wooled sheep (merinoes), to take them up at night; and least of all should merinoes be hurdled in wet weather, where the soil is *coloured red from the large quantity of iron it contains*; for, in that case, the wool will acquire a very bad condition, and be capable of being washed clean with difficulty, if at all. Sheep which have been shed-fed in summer, are, on the other hand, *washed clean with far greater ease when hurdled for fourteen days before shearing.*

839.—8. By the treading of the sheep, both in and out of the shed, much of the excrement is wasted, whilst *little or none of it is lost when it comes immediately on the pasture within the hurdles.*

840.—9. In fold-manuring *we save much straw,* which may be either reserved for the winter, or will serve as litter or fodder for cows fed in the stall.

841.—10. Lastly—The most important advantage of hurdling consists in this: that *a greater quantity of manuring matter is obtained*; for, on the one hand, the best portion of the excrements are not wasted by evaporation, which is always the case when they are collected together in the stall; and, on the other, the perspired vapours of the sheep, consisting of carbonic acid and ammonia, are absorbed by the soil, if it has been previously ploughed and loosened. In consequence of the excrements not lying together in large heaps, they do not undergo *so quick a decomposition as in the stall;* and while much ammonia is uselessly evaporated in the shed, none at all is lost in the fold-manuring, for as soon *as a little ammonia is produced, it is immediately absorbed by the soil, and chemically combined with the humic acid it contains.**

842. *Why is the cutting of clover generally better than "feeding it off?"*

Because every leaflet upwards has a rootlet downwards, and *if a leaflet be taken off, the rootlet will not grow*; so that if sheep be fed upon the surface, the constant cropping of the leaves diminishes the under-production. *In exact*

* Professor Spregnel.

"In threshing out fitches, one point I will shew;
First thresh out for seed of the fitches a few;
Thresh few for thy plough-horse, thresh clean for the cow;
This order in Norfolk good husbands allow."—TUSSER.

proportion to the upper, is the increase of the lower; and if you are *always feeding* off the former with sheep, you will *have but few roots below*, and the small amount of nutriment given in the shape of *oil-cake*, will produce *little or no effect.*

843. A friend of mine tried this in Northamptonshire. He had a field of clover, which he divided into two parts. The whole was cut at Midsummer, *half was left to grow again*, and *the other fed off.* In October, he staked out two pieces as regularly as possible, and had all the roots dug up, and carefully cleaned and weighed. The result was, that where the clover had been cut once and eaten once, there were *thirty-five hundredweight of roots per acre;* and where it had been cut twice, there were *seventy-five hundredweight per acre;* being a difference of TWO TONS of roots per acre. Who will say, then, that two tons of vegetable matter, *containing so much nitrogen as these roots do, were not an exceedingly good dressing?* Of course, the result in the wheat crops was perceptible at once; and you may depend upon it that, *with one exception*, namely—when the soils are so light that the mechanical treading of the feet of sheep is a prime necessity, *you will always get a better crop of wheat after two cuts of clover than by feeding off.**

844. *Why does hoeing promote the growth of plants?*

Because the *more a soil is pulverized*, and the greater the state of division in which its parts are, *the greater is its absorbent power.* The action of the hoe *increases the attraction for moisture*, encourages the circulation of the atmospheric and nutritive gases, and thus, be the soil what it may, *adds to its fertility.*

845. Hoeing also *destroys weeds*, which, if permitted to grow, crowd round the root of the plant, and, by *robbing the soil of its fertilizing matters*, and preventing the *free access of air*, materially *lessen the produce of the corn crops.*†

* Nesbit's "Lectures on Agricultural Chemistry."

† J. Hannam.

"To teach and unteach, in a school is unmeet,
To do and undo, to the purse is unsweet;
Then orchard or hop-yard, so trimmèd with cost,
Should not, through folly, be spoilèd and lost."—TUSSER.

846. *By the mechanical operations of agriculture*, we divide and enew the surface, and endeavour to make every atom of the soil ccessible to the action of the carbonic acid and oxygen of the tmosphere. In this way we *distribute the excess of mineral food 'ound at one spot to others in which it fails*, and thus enable a ew generation of plants to find everywhere the materials which re indispensable to their growth and prosperity.*

847. *Why is the system of late hoeing injurious?*

Because, by deferring the operation of hoeing, weeds cquire strength, rob the crop of its legitimate food, and t last become so deeply rooted, that the labour of the ioe is greatly increased; and is attended with danger to he cultivated crop.

848. If you cut off the roots of a tree, it will send out two new roots 'or every one that is cut off, and the tree may not be injured. Some hink it will become more vigorous. But if you cut the roots of corn, fter it has silked out, and thus force it into the business of forming ew roots, at the very time when it should be maturing its seeds, you commit a fatal mistake. You might just as well bleed your horse half o death, and work him hard in order to fatten him, especially if you ould keep him rather short the while, as corn is, of course, kept short, hile it has few unmutilated roots to convey its food.†

849. The use of the hoe for any of these purposes requires dry reather. The best hoe, when deep stirring the soil between drilled crops is performed, is the Spanish hoe, *fig.* 1, or the Vernon hoe, *fig.* 2. The flat, or common hoe, is only useful in cutting down weeds; and, as it is used in general, it performs little more. Hoeing between rows of crops is sometimes performed by what is called a hoe-plough, which s a small plough having a share with double fins, drawn by one

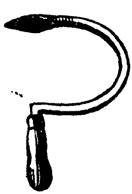


Fig. 1.

Fig. 2.

* Liebig. † J. A. Nash.

"At Christmas, good husbands have corn on the ground,
In barn and in soller, worth many a pound;
With plenty of other things, cattle and sheep,
All sent them (no doubt on) good houses to keep."—TUSSER.

man and pushed by another. The Dutch hoe is very useful for this service, and may also be efficiently used for the purpose of cleaning walks, or scraping turf or mud from roads or courtyards.*

850. *Why did the system of horse-hoeing husbandry, without manures, as adopted by Jethro Tull, fall into disrepute?*

Because it was founded upon an *extreme opinion*, the practice of which sought to accomplish *too much.* The important influence of the atmosphere on the soil, and the increased fertility produced by pulverizing and stirring heavy lands, led Jethro Tull to conclude *that labour might entirely supersede the necessity for manure:* hence the origin of the "*horse-hoeing husbandry,*" which at one time was so highly thought of as to be called, by way of distinction, the *new* husbandry, just as agriculture upon the modern theory is called *scientific* agriculture. *Fallowing* and *manuring* were *both discarded as unnecessary;* the seed was sown in rows with *wide intervals*, which were *continually worked and stirred.*

851. At first the result was highly satisfactory; all the *humus* (vegetable mould), by exposure to the air, was converted into *soluble extract*, and taken up by the plants, which throve well as long as the supply lasted; but in the end it was exhausted; and the warmest admirers and supporters of Tull's system found in practice that *pulverizing* ALONE *will not restore fertility.* The system of *drilling and horse-hoeing*, when UNITED WITH JUDICIOUS MANURING has, however, BEEN FOUND A GREAT IMPROVEMENT.†

852. The introduction of drill husbandry has been generally ascribed

* "Dictionary of Daily Wants." † Penny Cyclopædia: Art. "Arable Land."

> "The lands and the riches that here we possess,
> Be none of our own, if a God we profess;
> But lent us of Him, as his talent of gold,
> Which being demanded, who can it withhold?"—TUSSER.

to Jethro Tull, who wrote a work upon the subject in 1731. This, however, is incorrect. Sir Hugh Platt, in the year 1600, in his "New Found Arte of Setting Corn," recommended the system of "setting" in preference to "sowing," and described a board with a number of holes therein, which might be worked by two men, directed by a gardener's line, so as to keep them straight in the course of setting. He spoke, moreover, of this rude method having been previously tried, and of various opinions prevailing respecting it. But in Gabriel Platte's "Discovery," dating more than a hundred years previously to the days of Tull, the description of a drilling machine is most minutely given. He says:—"It is not intended that this work of setting of corne, should be generally put in practise at the first; but in every place a little in the most convenient and apt places, that so the people may be well skilled in it, and fit to follow it more earnestly in time of dearth and scarcitie, wherein so much corne may be saved for present releefe and necessitie, that it will be good as a general storehouse for the whole kingdome, for by this invention we doe as it were borrow of nature a multitude of quarters of corn for present maintenance of foode till the ensuing harvest."*

853. *Why is drilling superior to broad cast sowing?*

Because it admits of the *regular deposition of the seed at an uniform depth*, adapted to the habit of growth of the plant: from this there is *a saving of seed*, to the extent of at least *one-third*. It also *economises the use of manure*, by sowing the manure *in the spot where it may be available by the seed*, and not indiscriminately scattered through the soil. It also causes the plants to strike *at regular distances*, giving to each its appropriate space in the participation of *air*, *sunshine*, and *moisture*. And it facilitates the *cleansing of the soil from weeds*, &c., by the system of horse or hand-hoeing.

854. In 1848, Mr. Vernon Harcourt published a series of EXPERIMENTS showing *the difference between* DRILLING *and* BROADCAST

* Philp's

'In Spring-time we rear, we do sow, and we plant;
In Summer get victuals, lest after we want;
In Harvest we carry in corn, and the fruit
In Winter to spend, as we need of each suit."—TUSSER.

sowing; and the results, though not so decisively in favour of the former as Mr. Amos's previous trials, prove that, where the land was sufficiently uniform in quality to make all the circumstances of cultivation and growth equal, *the drilled part gave the greatest produce.* The following experiment is that upon which Mr. Harcourt places most reliance:—

	Grain.		Straw.	
	Bushs.	Gals.	Trusses.	lbs.
Drilled Wheat per acre	40	0	77	1
Broadcast per acre	33	3	66	24

855. This experiment gives an average equivalent to *an increase of fifteen and a half per cent. of grain from drilling, and of rather more than fourteen per cent. of straw.*

856. The drilling of *oats* and *barley* is much less common than that of *wheat.* The former of these being usually sown after lea, on one furrow, renders the drilling of the seed less advantageous in most cases. The same object, however, can be attained by *press-rolling the furrows,* either at the time of ploughing or afterwards. The seed although sown broadcast afterwards, mostly falls into the hollows of the furrows indented by the presser, and comes up in regular rows. On all stony and rocky soils, where a machine for drilling seed cannot be safely or effectively used, the press-roller may be very advantageously employed in *preparing a seed bed* either for *wheat, oats,* or *barley.* The seed can either be sown broadcast or delivered from a sowing apparatus attached behind the presser.*

857. Mr. John Beasley, an extensive farmer of Chapel Brampton, Northamptonshire, is an advocate for *sowing wheat thickly,* for the following reasons. He does it because, in his opinion, *corn ought not to be encouraged to* "tiller." If the plants are sufficiently *thick* in the spring, they *at once send up the stalk;* but, if the roots are *thin,* they send out *lateral shoots,* which *strike in the earth, and produce new plants.* The first plant is *weakened by having to produce auxiliary shoots;* and the plants of the *second growth* do not *come to maturity so early as the original, or parent plant.* The quality of the crop is thus injured, as there are always *more light* and *defective corns* in a thin-sown than in a thick-sown

* Morton's "Cyclopædia of Agriculture."

> 'Go look to thy bees, if the hive be too light,
> Set water and honey, with rosemary dight;
> Which set in a dish full of sticks in the hive,
> From danger of famine ye save them alive."—TUSSER.

crop; besides that, *there is less seed to meet the contingencies* of *wire-worm, grub,* or very *severe weather.** Mr. Beasley's *first* sown wheat is drilled at *eight inches apart,* with 2½ *bushels;* the *last* with 3 *bushels an acre.* The average crop for the six years preceding 1849 was 34½ *bushels an acre.*

858. *Why is drilling turnips on level preferable to "ridging," in certain instances?*

Because turnips *require moisture,* and are liable to be injured by drought, when ridged. The ridges, by the action of the sun upon their sides, sometimes become as dry as if they had been baked in an oven; and this is especially liable to occur, when the turnips are young, and require moisture, because their leaves are then not large enough to *shelter the ridges from the action of rain and wind.*

859. *For lands of a wet nature,* ridging has recommendations which it has not for that which is naturally dry—the spaces *between* the ridges become a species of surface drainage, and the farm-yard manure *within* them will have a similar tendency, which not only accounts in some degree for the ridge being more suitable for wet than for dry soils, but partly explains why *longer manure* may be used with advantage, on the former, than such as is considered proper for the latter. Again, the spaces also serve as a sort of railway for carts, &c., used in sowing the crops, as well as consuming it, thereby partly preventing the injury which wet land is liable to, from being "poached" in wet weather.†

860. *Why is liming preferable to paring and burning where the land is capable of being thoroughly broken and pulverized?*

In such cases it is better to lime grass lands immediately before ploughing, not only that the lime may assist in

* Caird's Agriculture.

† B. Almack, Prize Essay "On the Drill Husbandry of Turnips."

861. For similar reasons *lime may be used on corn stubbles*, before ploughing for turnips. It is best to lime *before ploughing*, especially if the land is foul, or if animal manure is intended to be applied to the turnip crops. Were the lime and the animal manure to *follow each other too closely*, the former might counteract the beneficial effects of the latter.*

862. *Why is it judicious in certain casses to let charlock grow, with a view to its extermination?*

The opinion has hitherto been entertained very generally —that it is *impossible to guard against having charlock in crops*, in support of which it has been said that, "If you dig the earth 20 feet deep, the soil coming to the surface from that depth would immediately be covered with charlock."

863. Now, of course charlock cannot grow where it is entirely out of the reach of the circulation of air ; and the same absence of air which prevents the seed from vegetating, may also preserve the vegetating quality.

864. If the land that is within the influence of the circulation of the air, be so worked as to allow all the seeds that lie latent within that depth to germinate, and when partly grown these are all destroyed, there remains a

* B. Almack.

"Now lop for thy fuel, old pollinger grown,
That hinder the corn, or the grass to be mown;
In lopping and felling, save edder and stake,
Thine hedges, as needeth, to mend or to make."—TUSSER.

cleaner soil, which may afterwards be worked without the detriment of over-running charlock.

865. One of the fields I had to sow with turnips had always been much subject to growing charlock, therefore I determined to make the whole of the seed, within the depth of the first ploughing, grow, that the plants might be destroyed. Having, by ploughings and harrowings, which were expressly intended to encourage the growth of the weeds, got the land thoroughly pulverized, the charlock sprung up so thickly as nearly to cover the whole surface of the land. I allowed it to grow to about two inches in length, and then had the land again dragged with the drag-harrow as before, the common harrow and roller again following each other as closely as possible; and the field thus prepared for a second crop of charlock. A second crop soon came, but it was a very thin one in comparison with the first, showing that I had caused the greater part of the seed to grow at once.

866. This process was repeated for the *third time*, the crop of charlock still diminishing; and when, after the *fourth* working, I sowed the turnip seed, it sprung up quickly; and I had the satisfaction to find these weeds were so effectually destroyed, that it would have been *difficult to find two within* 50 *yards of each other;* and it has NEVER GROWN SINCE, *although there have been several charlock years.**

867. *Why, in hoeing turnips, should the "chopping" system be avoided, and the hoe be worked with a firm steady hand?*

Because, if the "chopping" system is followed, the soil will in some places be removed too deeply, and probably the manure with it; and in others, the plants intended to be removed, will be imperfectly cut, or taken off above the ground, and after a few days they will so far recover as to

* B. Almack.

"If frost do continue, this lesson doth well,
For comfort of cattle, the fuel to fell;
From every tree the superfluous boughs,
Now prune for thy meat, thereupon to go browse."—TUSSER.

seriously impede the growth of those intended to be left single.

868. *Where the young turnip plants are very thin in the rows,* they may easily and readily be singled by the hoe alone; but, where turnips are very thick in the rows, it is desirable, if not actually necessary, that singlers should be employed. A man, with an active boy or girl, of about ten years of age, singling after him, will do in this case quite as much work in a given time as two men, equal as hoers, where they single their own plants. I have often heard this stated by good turnip-hoers; and in proof that they believed the advantage of singlers even greater than I have stated, I have seen men *take it in turn to single after each other early in the morning,* before their children arrived in the field, although, from the length of a man's back, he would much rather hoe than single. A child that will attend to proper directions may single turnips quite as well as a person fully grown; and indeed any increase of size tends to disqualify for the work. In all rows of turnips, some of the plants *from the first* take a decided lead of the others, and the difference would daily increase. Therefore the hoer must not be *too* particular about leaving the plants at regular distances; but take out those that are *decidedly marked as dwarfs,* even if he makes a space of two or three inches beyond what would otherwise be desirable, and for the same reason he must, in some cases, *leave the plants nearer together,* rather than go to the usual distance to leave one much inferior. The same reasoning will apply in singling, and the child should have directions accordingly. Where the hoeing is done by men, with children following them to single the plants, the hoe ought to be rather shorter than when each sets out his own. Therefore, if the average distance required is 10 inches, a hoe of about 8½ inches in length will be sufficient. I think that where this average distance is not adopted, a greater would be more desirable than a less space, especially for swedes.*

869. *Why is there always more "undercorn," or small ears, from drilling than from dibbling?*

Because the seed *goes farther into the ground from dibbling*

* B. Almack.

> "Young broom, or good pasture thy ewes do require,
> Warm berth, and in safety, their lambs do desire;
> Look often well to them, for foxes and dogs,
> For pits, and for brambles, for vermin, and hogs."—TUSSER.

than from drilling, the small end of the dibble piercing deeper than it appears, while the drill appears deeper than it is. Thus the set is more regular in depth and dibbled wheat stands up better against wind and rain; the latter is therefore most productive.*

870. The holes where the seed is placed, should be filled up *by a hurdle drawn with thorns*, and *not* with *harrows*, as is frequently practised. The first will nearly fill up the cavities, while the latter will very much *displace the seed*.†

871. *Why is dibbling less adapted to stiff soils than to others?*

Because, in the event of rain, immediately after dibbling the little earth-cups in which the seeds are placed *become filled with water*, which tends to rot the seed. For this reason the ground *should be harrowed immediately after dibbling*.

872. *Why should hay be cut before it is perfectly ripe?*

Because, in the blades and stems of young grasses, there is much *saccharine matter*, which, as the grasses grow, is gradually changed, first into *starch*, and then into WOODY FIBRE; and the riper the plant becomes, the more completely the latter change is effected, and *the less soluble and nourishing are the substances it contains.* The change may be illustrated by what takes place in *radishes* when they are allowed to remain too long in the ground: they become woody and tough.

873. The ripening of grass seeds, not only *seriously*

* Johnson's "Farmer's Encyclopædia." † Wm. Curtis, Lynn, Norfolk.

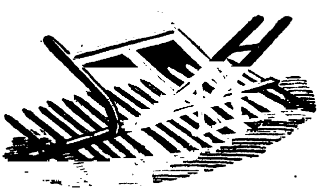
"In riddling of pasture, with turfs that lie by,
Fill every hole up as close as a die;
The labour is little, the profit is gay,
Whatever the loitering labourers say."—TUSSER.

injures the hay, but takes away a considerable portion of the *decomposable matters of the soil*; the exhausting effect upon poor land being very considerable.*

874. *Why should not hay be long exposed to the rays of the sun?*

Because, if exposed *too long*, it becomes roasted, first on one side, and then on the other. It is probable that this excessive drying *effects the conversion of starch into woody fibre*, after the hay is cut. Hence, the more *quickly* the drying is effected, the less extensively will changes of this kind take place. Hay should be *frequently* turned, and RAPIDLY dried during the "saving."*

875. An effective hay-rake is used in America, from whence it has found its way to England. It consists of a head perforated with 18 transverse teeth, which are firmly fixed. These teeth are slightly tapering to each end, where they are rounded off to a blunt point, but chiefly upon that side which is to be next the ground. It is drawn by a horse yoked to the draught-frame. In the working of this rake, it lies nearly flat upon the ground; and, when the draught-frame is at its proper height, the connecting rod keeps the hanging frame just within the extremity of the teeth that are then behind, and nearly bearing upon them. The working of this mechanism is, that in the course of its progression the rake collects the hay upon it chiefly in the front part; and when the attendant sees that the rake is filled, he raises the handles, and tilts the rake, leaving the collected mass at the spot where the tilts occur.



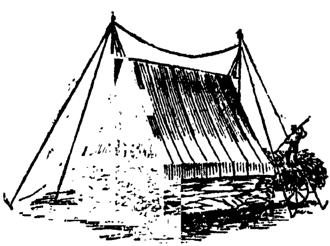
* Karkeck's "Essay on Fat and Muscle."

"By brambles and bushes, in pasture too full,
Poor sheep be in danger, and loseth their wool;
Now, therefore, the ewe upon lambing so near,
Desireth in pasture, that all may be clear."—TUSSER.

876. *Why does "sweating in the stack" improve the qualities of hay?*

Because it has the effect of rendering the fibres of the grasses more tender and changing part of the parenchymous [cellular, or pithy] matter into *sugar*, on the same principle as is effected in the *malting of barley*. This sweet taste renders the hay more palatable to horses.

877. Great care is requisite in the stacking of hay; for if not put together in a proper condition, it is liable to an excessive fermentation, from which it may take fire. While forming, the stack should always be covered with rick-cloths supported by poles and ropes, in the manner illustrated. Immediately after the stack has been built, a heat will arise



in it corresponding with the degree of fermentation the hay is undergoing. While this is proceeding, the stack subsides in bulk, and after the fermentation and subsidence have ceased, the stack should be thatched. But, should fermentation continue so long as to affect the quality of the hay, means should be used to put a stop to it, by shoring up the stack on both sides with stout posts, to admit of the free access of cool air. As a preparatory operation to the thatching, after the removal of the rick-cloth, the sides and ends of the stacks are neatly trimmed from angle to angle, with a small increase of breadth to the eaves. The operation simply consists of pulling out the straggling ends of hay, which give a rough appearance to the exterior, in order to render it smooth; and its use is twofold—to preserve the hay pulled out, which would otherwise be rendered useless by exposure to rain, and to prevent moisture hanging about the stack. The heading or thatching is composed of straw and straw-ropes; and these

should be prepared beforehand, so as to be ready by the time they are wanted. The thatching should be carried on both sides of the stack simultaneously by two, and begun at the same end.

878. *Dutch Barns* are in general use in Holland for storing hay. This contrivance, as seen in the annexed engraving, comprises a floor of a pentagonal form, a roof slenderly built, and covered with thatch, and upright poles so contrived that they may regulate the height of the roof as required. The purpose of this barn is, that hay may be stored in it, in large or small quantities, the roof being raised or lowered, according to the increase or decrease of the supply, by means of a jack, such as is used for lifting waggons when the wheels are taken off.*

879. *Why do hay-ricks become mow-burnt from excessive fermentation?*

Sometimes hay is *put into the stack while too much of the sap is yet retained;* the fermentation, therefore, becomes too great, and if it should escape being fired, it at least loses much of its fragrant smell, acquires a dark brown colour which increases towards the centre, and thus becomes what is called *mow-burnt.* Hay in this condition is said to weaken horses, by promoting an excess of urine.

* "Dictionary of Daily Wants."

"If hop-yard or orchard ye mean for to have,
For hop-poles and crotches, in lopping go save;
Which husbandly spared, may serve at a push,
And stop, by so having, two gaps with a bush."—TUSSER.

880. It is the custom of many farmers to *ventilate the hay stacks* by means of funnels in their interior, in order to prevent the hay from becoming mow-burnt, by drawing off the hot vapour occasioned by fermentation; and various methods are adopted to effect that purpose—such as square troughs bored full of holes, or nailed together with laths, or with sacks full of straw, which are placed upright, and the hay trod round them as the making of the stack proceeds, until the sack is nearly buried, when it is drawn up a little, and the hay laid round it as before. The advantages supposed to be thus gained are, however, counteracted by the parts on every side of such vents becoming mouldy, unless a free thoroughfare be secured for the air underneath; and in case of a current being thus admitted into the stack, it then greatly increases the risk of fire. It is, therefore, justly reprobated by every skilful haymaker, and should only be resorted to when occasioned by *wet weather*; in which case *the danger may be partly prevented by mixing the hay with layers of straw.**

881. *Why do hay-ricks sometimes spontaneously ignite?*

When hay is put together in a damp state, it undergoes *fermentation*; this involves chemical changes, attended by the *development of heat*. Among the constituents of hay, is *phosphorus*, which combining with *hydrogen* set free from the fermenting hay, forms a gas, inflammable at the temperature of boiling water. As soon as the necessary degree of heat is developed by fermentation, *the gas ignites*, and the heated rick, already in a state of slow combustion, is rapidly consumed.†

882. When spontaneous combustion occurs in vegetable substances, in every instance *either phosphorus, or one of its combinations*, or a vegetable essential oil, with some light fibrous matter, is present. Dr. Henry states that

* "Library of Useful Knowledge."

† The reader who wishes to study the interesting science of Chemistry should consult the "Chemical Reason Why," in which many chemical processes, more or less affecting Agriculture, will be fully and familiarly explained.

> "House calf, and go suckle it twice in a day,
> And after a while, set it water and hay;
> Stake ragged to rub on—no such as will bend;
> Then wean it, well tended, at fifty days' end."—TUSSER.

the expressed oils possess the property of inflaming any light vegetable matter or carbon, with which they may may come in contact. *Hay*, *charcoal*, *rags*, *dung-hills* and *pigeon's dung*, with many other substances, have long been reported to be liable to spontaneous combustion.*

883. The following rules will prove of value to the hay-maker :—

884. *First.* He must remember that the chief point is to *preserve the hay from dew or rain*; water washes away the soluble salts and other matters, and, when in the stack, will cause *fermentation*, and that injures the hay by *destroying some of its most valuable properties;* therefore, bring it into windrows, or make it into footcocks at nightfall, and *never open it in the morning until the dew has evaporated.*

885. *Second.* Bear in mind that, if the weather is unfavourable, *the less hay is disturbed the better*, and the longer will it retain its native powers. Hay has been found to preserve a great amount of its nutritive qualities for *many days*, nay, *even weeks*, when mown wet, or when saturated with the rains whilst lying in the swath; *if*, therefore, the weather be unfavourable, it will be better *not to tedd the hay at all*, nor even turn over the swath. If repeatedly dried and wetted again, it soon becomes valueless; this error of meddling with hay amongst frequent showers must, if possible, *be avoided*, for it is far better to have it somewhat tainted in the haycock, than thus *exhausted of its nutriment, and spoilt, by being repeatedly spread.*

886. *Third.* Take care *not to allow it to remain long under the hot beams of the sun without being turned.* This will preserve the colour and fragrance of the grass; so that, without baking it too much (thus destroying its virtues), it may be so dry that as little heating or fermentation as possible shall occur in the stack, remembering, also, that *coarse grass does not require so much "making" as fine succulent herbage.*†

887. *Why should cereals be reaped before they are fully ripe?*

The experiments conducted by Mr. Hannam show a

* Partington's Cyclopædia. † Morton's Cyclopædia.

gain of four per cent in favour of cutting wheat *a fortnight before it is actually ripe.* In addition to this benefit, as regards the *grain,* Mr. Hannam alleges the following additional advantages :—

1st. *Straw of a better quality.*

2nd. *A better chance of securing the crop; and,*

3rd. *A saving in securing it.*

And he enforces his views by the following among other arguments :—In all grasses, and succulent plants, *the greatest proportion of saccharine matter is present before the flower is dead ripe.* So in wheat, when we allow the straw to remain till thoroughly ripe, a portion of the sugar is converted by the action of light, heat, &c., into mucilage, and a great portion of the grass is absorbed by the atmosphere, or lost; and hence there is a great difference between straws or leaves that have been dried after they were cut in a succulent state, and those which are *dried while growing.* The former retain all their nutritive powers, but the latter, if completely dry, very little, if any.

888. As a manure, too, the straw cut *raw,* is superior to the *ripe;* for, as it is an agricultural axiom that the better the food of an animal is, the better the manure from it,—the manure from a stock consuming straw, *containing a fair proportion of nutritive matter,* must be more valuable than that *from stock consuming them ripe, with scarcely any nutriment in it.**

889. *Why, when green crops are to be employed for*

* J. Hannam "On Reaping Wheat." Quarterly Journal of Agriculture, 1841.

"Good milch cow, well fed, and that is fair and sound,
Is yearly, for profit, as good as a pound;
And yet by the year, have I proved ere now,
As good to the purse, is a sow as a cow."—TUSSER

manure, should they be ploughed in, where practicable, while in flower?

Because it is at this period that they contain *the largest quantity of soluble matter*, and that their leaves are most active in forming nutritive matter.*

890. *Why does the shading of grass lands with straw, or other fibrous matter, promote the growth of grass?*

This may be accounted for on the principle that *putrefaction, or solution of vegetable substances in the soil*, is more readily promoted by *a close or stagnated state of the air*, than by a constant supply and addition of oxygen from the pure atmosphere; or, in other words, that such a covering will *prevent the excessive exhalation of moisture, nitrogen, hydrogen*, and *carbonic acid gases*, which accumulate and thereby promote the putrefaction or decomposition of vegetable matters, and thus *enrich the soil*.†

891. Plants growing in the *shade* contain more *water* than those growing in full *sunshine*. Hence it is very probable that in those experiments which have been made on the increase of grass crops, by littering the fields with boughs, the increased product of an acre is due principally to *water*, rather than to any carbonaceous product, and consequently that the increase of the nutritive property is not in the ratio of the increase of weight.‡

892. *What is the system of "inoculating" grass land?*

It is pursued in the following manner:—A small plough is passed along an *old pasture*, from which it throws out about *three inches of turf*, returning again, and taking *another strip of the turf, but leaving a strip next to the one previously taken*, of the same breadth, until the requisite

* Sir H. Davy. † D. J. Browne's "Muck Book."
‡ Professor Hunt's "Researches on Light."

"Thy colts for the saddle, geld young to be light;
For cart do not so, if thou judgest aright;
Nor geld not, but when they be lusty and fat,
For there is a point, to be learnèd in that."—TUSSER.

quantity is obtained. A *corn drill* is then *passed over the ground to be inoculated*, the coulters of which mark it off in rows at *eight inches apart*. The sod is then cut into LITTLE PIECES, and *laid down in the rows*, each two pieces being about *four inches apart*. This is done by men, who *tread the squares of turf into the ground*. This being done in the *autumn*, the following *spring* the ground is *rolled*, and a little *Dutch clover* is sown; after which the whole is allowed to feed itself, and *stock is put on in the succeeding autumn*. The object is to *obtain at an early period the natural grasses of an old pasture* on *newly laid out* land. By this process *a fine pasture is rapidly formed*, and on that portion *from which* the *strips have been cut*, the ground soon covers itself from the adjoining rows of grass.*

893. *Why does burning clay improve its fertile qualities?*

Before the clay is heated, the *silicic acid* is so firmly united to the *alumina*, that they cannot be separated. But they are rendered dissolvable by burning the clay, as are the variable quantities of *potash*, *soda*, and *lime*, which clays contain. To these alkalies, as well as to the greater porosity of the heated clay, it is to be attributed that a heavy clayey soil, which is impervious to the air, is converted merely by burning into a very fertile arable land, and that slightly burnt *bricks* yield a very efficient material for *manure*.

894. *Why are clay soils better adapted to the growth of cereals, &c., than to that of bulbs or tubers?*

Because *the roots of cereals being fibrous*, are better able to *penetrate the close mass of clayey earth. Wheat, barley*, &c.,

* Caird's Agriculture.

"Who hath a desire, to have store very large,
At Whitsuntide, let him give huswife a charge,
To rear of a sow at once only but three;
And one of them also a boar let it be."—TUSSER.

growing upon long stalks, and bearing weighty ears, *require a strong hold of the ground.* Clay is also adapted to such plants as are furnished with tap-roots, such as *wheat, beans, red-clover,* &c.

895. *Why do leguminous plants prefer calcareous soils?*

Because *lime* is an important constituent in their composition: thus in *beans,* 100 parts of the ashes of the whole plant contain about 35 per cent. of lime; *peas,* from 6 to 10 per cent., with large quantities of potash and soda; *sainfoin,* about 26 per cent.; and *red-clover* from 25 to 30 per cent.*

896. *Why may the leaves of plants be regarded as indicating the kind of tillage they require?*

Because the leaves of all plants are the avenues through which they derive a material part of their sustenance, and their sizes and number afford a correct criterion *of the amount of nutriment derived from the aërial source.* Thus *beans,* and other *pulse* obtain *more food from the atmosphere* than *cereal plants;* roots *more than the former;* and *wheat,* from the small size of the leaves, *less than any.* Thus only can we account for the striking fact that if we give a good supply of inorganic elements *only* to the turnip crop, we shall very probably have a plentiful crop; whilst if these be absent, however rich the manure may otherwise be, the crop will be a failure. Not that we must draw the conclusion that the organic manures are of little or *no* importance to root crops; they are of value, and particularly *to the grain crops which succeed.*†

* J. Coleman.
† W. C. Spooner, Journal of the Royal Agricultural Society, Vol. VII.

"Calves likely that come, between Christmas and Lent,
Take huswife to rear, or else after repent
Of such as do fall, between change and the prime,
No rearing, but sell, or go kill them in time."—TUSSER.

897. *Why should the rotation of crops be determined according to local and climatic influence?*

Because there are at least three conditions which affect the interest of the farmer in the production of crops. These are *climate, nature* of *soil*, and *local position.* Some plants are best adapted to a *dry*, some to a *moist* climate; one is suitable to a *stiff clay* soil, another to a *loam*, and a third to a *sand;* the *local demand* for a particular crop may render its culture, even on a soil not the best adapted for it, remunerative; while *the absence of such a demand*, may make the same crop, on the best soil, of little value.*

898. Among many, *the golden rule of farming is—that no two* white crops shall follow in immediate succession; but the successful practice of a contrary system in some districts may teach us how vain it is *to prescribe the* SAME RULES *for totally* DIFFERENT CIRCUMSTANCES,—the same husbandry for the land with 20 inches of rain per annum, as for land with 40 inches of rain. *The true test of any system is its continued success*, and the practice of the best farmers in this district [South Lancashire], and whose farms are in the highest state of cultivation, producing crops of all kinds, which would astonish some of the wisest sticklers for rotation, combine in attesting the advantage in every point of view of *taking a crop of either barley or oats* IMMEDIATELY AFTER *the wheat crop.* The *four-course farmer* takes his crops in this succession:—1. *clover*; 2. *wheat*; 3. *turnips*; 4. *barley.* The Lancashire farmer PREFERS IT THUS:—1. *grass*; 2. *green crops*; 3. *wheat*; 4. *oats* or *barley*; his two green crops *following one another*, and his two white crops *the same.*†

899. *Why will an oat crop frequently grow well on heavy land?*

Because oats seem to like a soil *containing large*

* Morton's Cyclopædia. † Caird's Agriculture.

"Ruddy milkmaids weave their garlands gay,
Upon the green to crown the earliest cow;
When mirth and pleasure wear a joyful brow;
And join the tumult with unbounded glee
The humble tenants of the pail and plough."—CLARE.

quantities of vegetable matter in a state of decomposition, combined with a sufficient amount of *mineral ingredients;* consequently it is almost always the first crop grown on new land—often put in, as soon as the sod is turned. The oat crop *requires less mineral than the wheat;* the straw is more flaggy, and less strong, and contains a larger proportion of organic matter. Hence it succeeds where wheat would almost certainly fail. The wheat crop requires *more silica, phosphoric acid,* and *alkalies,* than either oats or barley, and this may in some measure explain its particular *habitat.**

900. *What has been the observed relative effect of improved farming upon wheat and barley?*

It is stated as a consequence of improved farming, that *the produce per acre of barley does not increase in the grain, so much as in the straw.* But, in fact, *the highly cultivated* BARLEY CROP RUNS TO STRAW, *to the* INJURY OF THE CORN; while, on the contrary, the WHEAT CROP increases in YIELD OF GRAIN with the higher cultivation. During fourteen years, on Mr. Thomas's farm, Liddlington, Bedfordshire, the *improved cultivation of wheat and barley,* produced an *average of* 35 *bushels* of WHEAT *to the* acre, and of BARLEY 42½ *bushels*—the former *progressing,* the latter *stationary.* The respective average value of the two crops during the same period was, of

Wheat, per acre	**£13**	**3**	**6**
Barley, per acre	**8**	**6**	**0**
Difference ***in favour of wheat,*** **per acre** .	**£4**	**17**	**6†**

* J. Coleman.

† Caird's Agriculture.

> "Those dusky foragers, the noisy rooks,
> Have from their green high city gates rushed out,
> To rummage furrowy fields and flowery nooks;
> On yonder branch now stands their glossy scout."—THOS. MILLER.

901. *Why should stones be picked from the surface only in certain cases?*

Because they exercise a beneficial influence, and in many cases would in time disintegrate and deepen the soil. Of course they must be removed where so large as to interfere with cultivation; but the benefit is very doubtful in other cases. The presence of stones scours the plough, as it is termed; that is, keeps the share and turn-furrow clean.*

902. Small stones should never be picked off from sandy soils, as they answer many valuable purposes: they shelter the young plants in bad weather; they preserve moisture, and prevent the young crops from being burnt by scorching heats; they hinder the evaporation of the enriching juices; and by these means assist the progress of vegetation. If stones are of a porous quality, they absorb moisture when it is redundant, and give it out when deficient. Hence farmers have been known to bring back again to their corn-fields, those very stones they had been induced to carry off.†

903. *What is the cause of the coldness of retentive soils?*

Coldness is caused chiefly by the *removal of the water of drainage, by evaporation.* That the evaporation of water produces cold is well known: it cools wine; in hot climates it produces ice.

904. To determine the actual *degree* of cold produced by the evaporation of one pound of water from soil, is rather a complicated, and not a very certain operation; but scientific reasons are given for

* Coleman's Prize Essay; Journal of Royal Agricultural Society.
† Sir John Sinclair's Code.

"Nor every plant on every soil will grow:
The sallow loves the watery ground, and low;
The marshes, alders; nature seems t' ordain
The rocky cliff for the wild ash's reign."—DRYDEN.

an approximation to this result—that the evaporation of one pound of water lowers the temperature of 100lbs. of soil 10°. That is to say, that if the 100lbs. of soil holding all the water which it can by attraction, but containing no water of drainage, is added one pound (or pint) of water which has no means of discharging except by evaporation, it will, by the time that it has so discharged it, be 10° colder than it would have been if it had the power of discharging this quantity by filtration.*

905. *Why are humid soils little benefited by summer heats?*

Because water, in a *quiescent state,* is one of the worst conductors of heat with which we are acquainted. Water warmed at the surface transmits little or no heat *downwards.* The small portion warmed expands, becomes lighter than that below, and consequently retains its position upon the surface, and transmits no heat underneath.

906. When water is *heated from below,* the portion first subjected to the heat rises to the surface, and every portion is successively subjected to the heat and rises, and each, having lost some of its heat at the surface, is in turn displaced. Constant motion is kept up, and a constant approximation to an equal temperature in the whole body.*

907. *Why does drainage elevate the temperature of the soil?*

Because, by removing the water of drainage, it *prevents that constant evaporation by which the surface heat of the earth is lowered.*

908. But it also acts in another way: many experiments have shown that, in retentive soils, the temperature at two or three feet below the surface of the water-table is, at no period of the year, higher than 46° to 48° in

* Gisborne's "Essays on Agriculture."

agricultural Britain. Drains placed two to three feet below the water-table, draw out water of the temperature of 48°. Every particle of water which they withdraw at this temperature is replaced by an equal bulk of air at a higher, and frequently at a much higher temperature. *The warmth of the air is carried down into the earth.* The temperature of the soil, to the depth to which the water is removed, is in course of constant assimilation to the temperature of the air at the surface.

909. From this it follows necessarily, that during that period of the year, when the temperature of the air at the surface of the earth is generally below 48°, retentive soils which have been drained are colder than those which have not. Perhaps this is no disadvantage. In still more artificial cultivation than the usual run of agriculture, gardeners are not insensible to the advantages of a total suspension of vegetation for a short period. In Britain, the land suffers, not from an excess of cold in winter, but from a deficiency of warmth in summer. Grapes and maize, to which sombre skies deny maturity, come to full perfection in many regions whose winters are more severe.*

910. *Why should the water-table, in drainage operations, lie four feet from the surface of the land?*

It is too commonly regarded as sufficient to sink the drains nearly *out of the way of the plough*, and of *the feet of cattle;* or at most out of the reach of sub-soil implements. But there are reasons, founded upon ascertained facts, and the acknowledged principles of vegetation, why drainage systems should be deeper laid.

911. Every gentleman who, at his morning or evening toilet, will take his well-dried sponge, and dip the tip of it into water, will find that the sponge will become wet above the point of contact between the sponge and the water, and this wetness will ascend into the sponge, in a diminishing ratio, to the point where the forces of attraction and

* Gisborne's Essays.

"Often at early seasons mild and fair
March bids farewell with blossoms in her hair
Of hazel tassels, woodbine's brushy sprout
And sloe and wild-plum blossoms peeping out."—CLARE.

gravitation are equal. This illustration is for gentlemen of the Clubs, of Drawing-rooms, of the Inns of Court, and for others of similar habits.

912. For gentlemen who are floriculturists, we have an illustration much more apposite to the point which we are discussing. Take a flower-pot a foot deep, filled with dry soil. Place it in a saucer containing three inches of water. The first effect will be, that the water will rise through the hole in the bottom of the pot, till the water which fills the interstices between the soil is on a level with the water in the saucer. This effect is by gravity. *The upper surface of this water is our water-table.* From it the water will ascend by attraction through the whole body of soil, till moisture is apparent at the surface. Put in your soil at 60°, a reasonable summer heat for nine inches depth, your water at 47°, the seven inches temperature of an undrained bog; the attracted water will ascend at 47°, and will diligently occupy itself in attempting to reduce the 60° soil to its own temperature. Moreover, no sooner will the soil hold the water of attraction, than evaporation will begin to carry it off, and will produce cold consequent thereon. This evaporated water will be replaced by water of attraction at 47°, and this double cooling process will go on till all the water in the water-table is exhausted. Supply water to the saucer as fast as it disappears, and then the process will be perpetual. The system of saucer watering is reprobated by every intelligent gardener; it is found by experience to chill vegetation; besides which, scarcely any cultivated plant can dip its roots into stagnant water with impunity.

913. Exactly the process which we have described in the flower-pot is constantly in operation on an undrained retentive soil: the water-table may not be within nine inches of the surface, but in very many instances it is within a foot or eighteen inches, at which level the cold surplus oozes into some ditch or other superficial outlet. At 18 inches attraction will, on the average of soils, act with considerable power. Here, then, you have two obnoxious principles at work, both producing cold, and the one administering to the other. The obnoxious remedy is to destroy their *united* action; to *break through their line of communication.* Remove your water of attraction to such a depth that evaporation cannot act upon it, or but feebly.*

* Gisborne's Essays.

"They keep a bulky charger near their lips,
With which, in often interrupted sleep,
Their frying blood compels to irrigate
Their dry furred tongues."—PHILIPS.

914. "Take this flower-pot," said the President of a meeting in France; "what is the meaning of this small hole at the bottom? to renew the water. And *why renew the water?*—because it gives life or death: LIFE, when it is made only to *pass through the bed of the earth,* for it *leaves with the soil its productive principles,* and *renders soluble the nutritive properties destined to nourish the plant;* DEATH, on the other hand, *when it remains in the pot, for it soon becomes putrid,* and *rots the roots, and also prevents new and nutritive water from penetrating.*" THE THEORY OF DRAINAGE IS EXACTLY DESCRIBED IN THIS FIGURE.*

915. *Why is the irrigation of lands of great importance to agriculture?*

Because it affords a means by which the rich organic and other matters diffused through rivers, *which would otherwise be carried into the sea, may be saved to agriculture.* This is not, therefore, a question like that attending most other modes of fertilizing the soil, merely *transposing manure from one field or district to another;* but it is the absolute *recovery,* as it were, from the ocean, of a mass of finely divided enriching substances *constantly draining from the land.* It is the effectual division of a stream which is ever steadily impoverishing all cultivated soils, and which unnoticed, and in too many instances deemed worthless, gliding into the ocean, *is almost the only drawback to the steadily increasing fertility of any country.*†

916. *Example of Improvement.*—A most notable instance of the benefits of irrigation, is to be found in the famous Craig entwining Meadows, near Edinburgh, where about 300 statute acres are thus irrigated by the stream flowing from the city sewers. The water runs naturally by gravitation over the greater part of the area, but it has to be lifted about 15 feet by steam power, to admit of distribution over a portion of about 60 acres more recently brought

* Lavergne's "Rural Economy."
† Johnson's "Farmer's Encyclopædia.

"And though the thorns withhold the May,
Their shades the violets bring;
Which children stoop for in their play,
As tokens of the Spring."—CLARE.

under this system of cultivation. The oldest part of the tract, containing about 220 acres, is laid out on the catch-meadow principle, common in the west of England; the remainder is artificially levelled and arranged in "panes" of about 1½ acres—a plan involving greater first outlay, but which is said to be more efficient in working. The productiveness is almost entirely dependent on the irrigation, the soil of the old meadows being a hard sterile clay, but another portion, reclaimed from the sea in 1826, consists of sand and shingle, with no soil at all, except what the sewage has created. The average cost of laying out the whole ground was about £15 per acre; the total capital invested about £5400; exclusive of the original value of the land, 30 acres of which were worthless, and the rest a heavy untractable clay. The annual expenses of the irrigation, exclusive of interest, are £256 14*s*. 6*d*. The lowest rental obtained is £9 per acre, and the highest £31; the average of the whole being more than £20 per acre. From four to five crops of grass are taken off every year, the collective weight in parts being stated at the extraordinary amount of 80 tons the imperial acre. The quantity of sewage-water laid on is from 8000 to 9000 tons per acre, but only a small portion of the fertilizing matter, contained in this enormous mass, can enter the ground under the combination of irrigation and manuring: the greater part flows off the land with the water into the sea. Mr. Bryce, the manager, states "that *the action of the sewage-water is not a sudden impetus, followed by reaction and exhaustion, but the land goes on increasing in value, according to the length of time the system has been in operation.*"*

917. *Why should thorn hedges be kept carefully trimmed?*

Because the strength of the fence is greatly increased by the practice of a *wide bottom.* When thorns are allowed to grow to unequal heights, the strong plants are sure to smother the weak ones; and when the hedge becomes hard at the top, it retains water and snow, to the great injury of the plants. It is an easier business to *root up an old hedge* and *train a new one,* than to *recover*

* Bath and West of England Agricultural Society's Journal.

"The royal husbandman appeared
And ploughed, and sowed, and tilled,
The thorns he rooted out, the rubbish cleared,
And blessed th' obedient field."—DRYDEN.

a hedge which has been *mismanaged*, or suffered to *get into bad condition*, from want of attention to the clearing and cutting processes.*

918. *Why are large fences to small enclosures prejudicial to good farming?*

Because when lands are encumbered with hedges and hedge-row trees, they are utterly incapable of profitable cultivation. In some cases the *fields* are so *small*, and the *trees* are so *large*, that *their roots actually meet* from the opposite sides, and *pervade the entire surface soil of the area enclosed by them.* When manure is applied to such fields, it is *monopolized by these freebooters*, and the crops of grain or hay, such as they are, are so screened from the sun and wind, that there is great risk of their being spoiled in the harvesting. *If drains are made* in such fields, they are speedily *filled up by the rootlets*, and thus rendered *useless*.†

919. *Why should white thorns for hedges be planted in single rows?*

Because, planted in double or triple rows, the thorns are of stunted growth, and the fence becomes completely choked. The double or triple rows are attended with the inconvenience of not easily admitting either the hand or tools to clear them, after the first year; the single row is not only more easily cleared, but for the most part advances with greater vigour, and becomes a stronger and a better fence than when more rows are planted; although the double or triple rows have usually a more promising appearance for the first year or two.

* Brewster's Encyclopædia. † Encyclopædia Britannica.

"Strength may wield the ponderous spade,
May turn the clod, and wheel the compost home;
But elegance, chief grace, the garden shows."—COWPER.

IV.

GARDENING PRACTICE: APPLICATION OF THE PRECEDING PRINCIPLES TO GARDENING; MANURING; PLANTING; TRANSPLANTING; BUDDING; GRAFTING; PRUNING; TRAINING; RINGING; HYBRIDIZING; BLANCHING; GATHERING; ETC.

920. We wish to make gardeners *thoughtful as to the principles on which all successful operations depend*, and thus to take their pursuits as much as possible out of the domain of chance. Many first-rate minds are constantly occupied in investigating the modes in which vegetable growth proceeds, and the conditions on which its full development depend; but most gardeners neglect altogether this interesting study. As successful practice is all that is contemplated by the knowledge of the abstract principles of an art, we are not disposed to find fault with those useful men who are satisfied when they can produce fine flowers, and fruits, and vegetables, by experience only. At the same time *we can see no reason why every one who takes pleasure in horticulture should not, while working with his hands, exercise his mind at the same time on the phenomena presented to him.**

921. *Why should vegetable refuse be dug in fresh in garden soils?*

Because the vegetable refuse of a garden requires a *length of time* before it can be decomposed; and in whatever part of the garden or ground the heap may be placed, it has always an *unsightly and slovenly* appearance. Add to this, that the heaps lose nine parts out of ten, not only of their size and substance, but also of their most valuable qualities, *by the continual action of sun, air,* and *rain* upon them. But if the refuse is buried beneath the surface of the ground while fresh and green, it is then of easy solution. The *moisture of the earth assists the fermentation*

* Rev. H. Burgess's "Amateur Gardening."

'When the bare and wintry woods we see,
What then so cheerful as the holly-tree?"—SOUTHEY.

and *decomposition;* and the *juices being preserved in the soils* become the nutriment and support of succeeding crops.

922. The *cabbages, cauliflowers, brocoli, potatoes, peas, beans,* &c. are planted in my garden, as in most others, in straight rows, or drills. Before the gardener mows the lawn and pleasure ground, he is directed to open a trench between these drills as wide as the space will admit without injury to the vegetables growing in the rows, and about nine inches in depth. The short grass mown upon the lawn is then carried into the trench, and trodden closely down till it is full, and the earth which had been removed, is again thrown upon it, and the ground raked smooth and even.

923. *Every time the lawn and walks are mown, the same course is followed,* till the whole kitchen garden is regularly and successively enriched with the most excellent vegetable manure. In a very few weeks, the short grass buried beneath the surface is decomposed, and incorporates with the earth; and where the peas and beans, and other vegetables are hoed and earthed up, it imparts a very great degree of vigour and luxuriance to their growth.

924. *But it is not the grass only that is converted to this useful purpose.* When the potatoes are dug, and the crop of peas and beans gathered, the potatoe haulm, the pea and bean haulm, the outer cabbage leaves, and the cabbage stalks, in short, *the whole vegetable refuse of the garden* to a great amount, is *buried in its fresh and green state* in the trenches, and far more than repays the nourishment that has been drawn from the ground.

925. At the end of October, the *asparagus* beds are dressed for the winter. The earth, to the depth of about five inches, is first drawn into the alleys; a vegetable coat of manure is then spread over the whole bed; and the earth from the alleys thrown upon the top again. The weeds by this process, are effectually destroyed, the bed is enriched, and the plants preserved from the effects of the cold and frost.

926. My *strawberries* are also planted in ranks or drills, and in the months of October and November, have their narrow intermediate trenches filled with the fallen leaves of trees, of which there is at that

"The flower ripens in its place:
Ripens and fades and falls, and hath no toil,
Fast-rooted in the fruitful soil."—TENNYSON.

season a very plentiful supply. Few plants profit more by this system than strawberries. From the rapid manner in which they exhaust the vegetable manure in the earth, they are observed to require frequently a change of ground, that is, to be removed to a soil where the vegetable manure has not yet been consumed.*

927. *Why may liquid manures be advantageously applied to plants in pots?*

Because the quantity of earth, which a small pot contains, soon becomes exhausted, relatively to one kind of plant, though it may still be fertile to another; and the size of the pot cannot be changed sufficiently then to remedy this loss of fertility. If it were ever so frequently changed, the mass of mould, which each successive emission of roots would enclose, must remain the same. *Manure can therefore probably be most beneficially given in a purely liquid state:* and the quantity which trees growing in pots have taken thus, under my care, without any injury, *and with the greatest good effect*, has exceeded every expectation.†

928. *Why should a system of crop rotation be observed in gardens, as in fields?*

Because the principles already explained in regard to *agriculture*, apply *also* to the *garden*, notwithstanding that the latter is generally more highly manured. It has long been known to gardeners that flowers and fruit trees *will not prosper so well* when planted in a situation where *others of the same kind have just previously been grown*, as if planted in situations *where they succeed to others of a different kind.*

* Rev. J. Venables.

† T. A. Knight, Esq., F.R.S., late President of the Royal Horticultural Society.

> "Some giants; some of middle stature be;
> Some dwarfs; reduced by art in infancy;
> Which, when disposed in spaces well designed,
> The shortest forward, and the tall behind."—LAWRENCE.

929. It is a well-established fact in forestry, that when a wood principally composed of one species of timber trees has been cleared, the trees which then *spring up spontaneously* and supply the place of the former growth, are for the most part of a *different species.**

930. The *temporary crops* in kitchen gardens require a *constant change*, as it is found from experience that the same crop *cannot be grown on the same ground for two years in succession,* without becoming of an *inferior quality;* and thus it is necessary to arrange that in each compartment *a fresh crop shall be grown every year,* as different as possible from the one that grew in it the year before. Thus, *onions* may be succeeded by *lettuces, carrots* by *peas, potatoes* by *cabbage,* and *turnips* by *spinach.* These plants may be varied according to circumstances: but the principle is NEVER TO HAVE TWO FLESHY-ROOTED PLANTS LIKE THE CARROT AND THE POTATOE TO SUCCEED EACH OTHER, *but always to let a plant cultivated for its* LEAVES *or* SEEDS *follow one cultivated for its roots.*†

931. *Why should the soil supplied to fruit trees be generally not more than eighteen inches deep?*

Because, if the roots strike so deep as to be *out of the reach of air,* the trees will produce an excess of *wood* and *leaves,* and but little FRUIT. When a fruit-tree border is in its proper state, the gardener is *able to show the fibrous roots of his trees by removing a little of the earth with his hand.*

932. *Why in manuring garden plants should regard be had to the duration of their existence?*

Because ANNUAL plants, *having but little time to fulfil the intentions of nature,* readily accept nutriment in almost

* Professor Henslow's "Descriptive and Physiological Botany."

† Mrs. Loudon's "Lady's Country Companion."

"The garden-flowers are reared for few,
And to that few belong alone;
But flowers that spring by vale or stream,
Each one may claim them for his own."—ANN PRATT.

any form in which it can be offered them: but trees, *being formed for periods of longer duration*, are frequently *much injured by the injudicious and excessive use of manure.* The gardener is often ignorant of this circumstance; and not unfrequently forms a compost for his wall-trees, which after stimulating them for a few years to preternatural exertion, becomes *the source of disease, and early decay.**

933. *Why do vegetables not assume a green colour, when the light is excluded from them?*

Because their tissues contain numerous globules, *filled with a resinous substance, which turns green under the chemical agency of light.* When light is not allowed to act upon these globules, the resinous matter which they contain remains white. The coloured globules of the cellules of flowers may be compared with these; though they are variously acted upon by the sun's rays. The resinous matter which thus becomes green, is by some chemists termed *chlorophylle*, but it may more properly be called *chromule.* The latter term may apply to *any colour*, the former only to *green.*†

934. *Blanching* consists of rendering vegetables white, by excluding them from the light. It is performed on *celery, chardoon, asparagus,* &c., by throwing the earth up around them as they advance in growth, so as to press the leaves, but leaving the heart free. Tying the leaves together of *lettuces, endive,* and *cabbage,* the heart becomes blanched by the consequent exclusion of light, as well as more crisp and tender. Laying tiles, slates, boards, &c., on *endive,* or other salading, when they are as large as required, is a common and easy mode of blanching. Placing flower-pots inverted, or other utensils over *sea kale, rhubarb, asparagus,* &c., is the preferable mode of blanching. In early spring, horse litter is placed round the outside of the pots,

* T. A. Knight, Esq., F.R.S. † De Candolle's "Vegetable Organography."

> "And 'tis, and ever was, my wish and way
> To let all flowers live freely, and all die
> Whene'er their genius bids their souls depart."—W. S. LANDOR.

to accelerate the growth of the vegetables under them, and by these means the crop will be early.*

935. *Why do leaves turn brown in the autumn?*

The *change in the colour* of leaves appears to be entirely dependent upon the *absorption of oxygen,* which all the green parts of plants have the power of absorbing, almost without intermission. This goes on *equally with the spring or the summer leaves;* but during these periods the vital force, under the stimulus of light, is excited in producing the assimilation of the oxygen *for the formation of the volatile oils, the resins,* and *the acids.* In the autumn, *this exciting power is weakened;* the summer's sun has brought the plant to a certain state, and it *has no longer the vital energy necessary for continuing these processes.* Consequently, the oxygen now acts in the same manner on the living plant, as we find in experiment it acts upon the dried green leaves, when moistened and exposed to its action. *They simply absorb gas and change colour.*†

936. *Why are the leaves of the vine, the walnut-tree, and the shoots of dahlias and potatoes often destroyed by frosts in valleys, but untouched upon surrounding eminences?*

Because *radiation* goes on upon the declivities of hills and elevated situations, and *the air which is condensed by cold,* rolls down and lodges at their feet. Their sides are thus protected from the chill, and a double portion falls upon, what many are apt to consider, the more "sheltered situation." It is a very old remark, that the injurious *effects of cold occur chiefly in hollow places,* and these frosts are *less severe upon hills than in the neighbouring plains.*

* Encyclopædia Metropolitana. † Hunt's "Researches on Light."

'In all the colours of the flushing year,
By Nature's swift and secret-working hand,
The garden glows, and fills the liberal air
With lavish fragrance."—THOMSON.

THE ADVANTAGES OF PLANTING A GARDEN UPON A GENTLE SLOPE, ARE HENCE APPARENT.*

937. *Why do grapes which are protected from flies by bags of black crape, ripen better than those that are tied in white crape?*

Because the *black* colour, being *favourable to the absorption of light*, permits a greater number of rays to pass through its meshes. But *white* crape has a *tendency to reflect*, or turn back the rays, and hence the fruit is less acted upon: but it is admitted that neither in white nor black crape will grapes ripen *so well* as those which are *freely exposed.*

938. *Why should not mats or screens intended for the protection of a plant be placed* in contact *with it?*

Because, when bodies are in *actual contact*, the laws of RADIATION are suspended, and those of CONDUCTION intervene. The screen, coming in contact with the plant, *absorbs heat from the vegetable body.*

939. *Why do palings, hedges, walls, &c., protect vegetation?*

Because the amount of evaporation from the soil, and of exhalation from vegetables, depends upon two circumstances—*the saturation of the air with moisture*, and the *velocity of its motion.* When the air is *dry*, vapour ascends in it with great rapidity, from every surface capable of affording it, and *the energy of their action* is GREATLY PROMOTED BY WIND, which *removes it from the exhaling body, as fast as it is formed.*

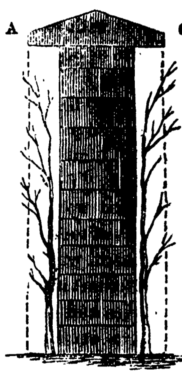
* J. F. Daniell, Esq., "Horticultural Society's Transactions."

"Some wooden fragments are the fittest rein,
Ungoverned shoots to guide, and to restrain;
The bud from northern blasts those walls protect,
And southern beams with double force reflect."—LAWRENCE.

940. Over the state of *saturation*, the horticulturist has no control in the open air; but he can *break the force of the wind* by artificial means, such as *walls*, *palings*, *hedges*, or other screens; or he may *find shelter* in situations upon the acclivities of hills. *Excessive evaporation is very injurious to many of the processes of vegetation, and no small proportion of what is commonly called* BLIGHT *may be attributed to this cause.**

941. *Why are the shoots of fruit trees which project beyond the copings of walls, frequently injured by frosts, while those within the line of the coping are unharmed?*

Because the coping affords *a check to radiation*, and therefore *preserves the temperature of the sheltered parts of the plant*. In the annexed engraving, A B C D represents a transverse section of a wall, covered with a coping A C.



942. An interesting fact illustrating this law, is recorded in the *Horticultural Transactions*, Vol. VI. In the instance of a very severe frost, all the shoots of the vines projecting beyond the perpendicular line A C, that is *beyond the salutary influence of the coping*, were quite *cut off by the frost*; but the trees *whose shoots did not project* beyond that vertical line were protected from injury.

943. *The effects of wide copings in favouring the growth of fruit*, are thus illustrated:—The copings of my wall have a considerably greater projection than is usual. I was induced to adopt this plan

* J. F. Daniell, Esq.

"A gardener who cultivates his own garden with his own hands, unites in his own person the three different characters of landlord, farmer, and labourer."
SMITH.

from several circumstances, which I will mention: I have observed that the fruit on clay walls is commonly superior, both in quality and quantity; these walls are *always finished with a covering of thatch,* for their preservation, which *projects at least nine inches,* and to this circumstance I attribute the abundance and excellence of the produce of the trees trained against them, arising from the ample shelter afforded to their blossoms during the spring season. I have also noticed for many years that a Moor Park apricot tree, planted to the south-west, under the projecting eaves of a low house adjoining my garden, never failed to produce large crops, without any other protection, whilst the blossoms of my own trees, in the same aspect, were frequently cut off, although guarded by a double netting, my wall having only a projection in the coping of a few inches; and I apprehend that the difference of success in these two causes could only arise from the difference in the width of the respective projections above them.*

944. There are no objects which disclose more remarkable phenomena connected with *radiation,* than the *different tribes of vegetables;* and the effects of hoar frost upon them are eminently interesting. *Every flower has a radiating power of its own, and so has every leaf;* differing in different plants, and varying in the same plant from exposure and position. The grasses disclose the same diversity; and while the Almighty seems in consummate wisdom to have adapted every plant, "from the cedar tree that is in Lebanon, even unto the hyssop that springeth out of the wall," to a locality in which the conditions of temperature and atmospheric humidity are best adapted to its general wants; it is worthy of observation how much an alteration of the circumstances in which nature originally placed it, seems to affect its energies and growth. To vegetables growing in climates, *for which they were originally designed by nature,* there can be NO DOUBT that *the action of radiation is particularly beneficial,* from the deposition of moisture which it determines upon their foliage; but to tender plants, *artificially trained to resist the rigours* of an unnatural situation, *this extra degree of cold may prove highly prejudicial.*†

945. *Mats, or canvas upon rollers, to draw down occasionally* in front of the trees, at the distance of a foot or two from their foliage, would be *a great advantage* in certain dry and cold states of the

* Rev. T. G. Cullum. † Encyclopædia Metropolitana.

"Or if the garden with its many cares,
All well repaid, demand him, he attends
The welcome call, conscious how much the hand
Of lubbard labour needs his watchful eye."—COWPER.

atmosphere; and, in the case of walls which are not opposed to others, would be a good substitute for the protection of the latter.

946. Trees trained upon a wall or paling, or plants sown under their protection, are at once cut off from a large portion of this evil; and are still further protected, if within a moderate distance of an opposing screen. The most perfect combination for the growth of exotic plants in the open air, would be a number of parallel walls within a short distance of one another, *facing the south-east* quarter of the heavens; the spaces between each should be gravelled, except a narrow border on each side, which should be kept free from weeds and other short vegetables. On the southern side of these walls, *peaches, nectarines, figs*, &c., might be trained to advantage, and on their *northern sides* many hardier kinds of fruit would be very advantageously situated. Tender exotic trees would thus derive all the benefit of the early morning sun, which would at the earliest moment dissipate the greatest accumulation of cold *which immediately precedes its rise*, and the injurious influence upon nocturnal radiation would be almost entirely prevented. Upon trees so trained, the absolute *perpendicular* impression could have little effect, and *this little might be prevented by a moderate coping.**

947. *Why will a frozen plant be preserved if it be plentifully drenched with cold water?*

Because the application of cold water produces *a gradual thaw*, whereas the *sudden elevation of temperature*, which would be occasioned by the morning sunbeams, or by water warmed thereby, would be fatal to the plant.

948. *Why are young shoots more readily destroyed by frost than old shoots?*

Because frost acts with a greater degree of intensity upon those parts of the plant *where the watery particles are most abundant*, as in young shoots; whilst those parts of the

* J. F. Daniell, Esq.

"Such, falling frequent through the chiller night,
The fragrant stores, the wide projected heaps
Of apples, which the lusty-handed year,
Innumerous, o'er the blushing orchard shakes."—THOMSON.

plant where the tissue is driest, and the secretions are most dense, will be more capable of resisting the frost.

949. *Why should frost-bitten bloom on fruit-trees be watered before sunrise?*

The condition of a frost-bitten vegetable appears to be analogous to that of a frost-bitten limb or joint, which is *recovered* by the application of cold water, but *injured and sometimes destroyed, by being brought near a fire, or the influence of sudden warmth.*

950. The gardener to James Wortley, Esq., of Wortley Hall, near Sheffield, observed that, in planting cabbages among rows of kidney beans, very early in the morning, after a frosty night in spring, before the sun was high enough to come upon the frosted beans, he *spilt some of the water* upon them, which he used in planting the cabbage plants, and, to his surprise, found that *the beans began immediately to recover.*

951. He subsequently adopted the following rule:—1. If, upon visiting the trees before the sun was up in the morning, after a frosty night, he found that there was *any appearance of frost in the bloom or young fruit,* he watered the *bloom or fruit thoroughly with cold water,* from the garden engine; and even when they were discoloured, this operation RECOVERED THEM, *provided it was done before the sun came upon them.* Sometimes he found occasion to water particular parts of the trees more than once in the same morning, before he could entirely get rid of the effects of the frost.*

952. The water, thus applied, serves *as a medium between the chilling cold and a warmer atmosphere,* by which a transition from the one to the other is effected, and the equilibrium, necessary for the preservation of the flower, GRADUALLY re-established. The frost having violently acted upon its organization, if the opposite extreme were *not once* substituted, an *entire destruction* of it would be the consequence; but *the cold water interposes between the sudden*

* "Horticultural Society's Transactions."

"So vermin bred in earth with dark designs,
Move from below, and often spring their mines,
On grass and gravel walks by night intrude,
Defiling both, unless they're close pursued."—LAWRENCE.

warmth, which would be pernicious, and *affords it a slow and gentle passage*, which enables the injured parts *by degrees* to recover. *It is the* SUDDEN *transition from heat to cold which destroys vegetables.**

953. *What are the great purposes fulfilled by vegetation?*

Without vegetation, man and inferior animals, as now constituted, *could not exist*. Animals AND vegetables are composed principally of *four* elementary principles—oxygen, hydrogen, nitrogen, and carbon; they pass from one condition, from one kingdom of nature, into another; the animal, perishing and dwindling by decomposition into the most simple forms of matter, mingling with the atmosphere as mere gas, gradually becomes part of the growing plant, and by like changes *vegetable organisms progress onward to form a portion of the animal structure.*†

954. *Plants were the first vital existences* which appeared when the fiery mass which constitutes the earth had become covered with a stony crust of a cooler temperature, and they are the last to linger when the rigours of a Polar clime chase away all vitality. They are still the sole inhabitants of isolated spots on the burning plains of Central Africa, and are the harbingers of animal life on the remotely issued lava, and the more recently emerged coral island of the Southern seas.

955. *They are found universally* within limits bounded, on the one hand, by the perpetual snows of the Arctic regions, or the summits of Snowdon; and, on the other, by the parched sands of tropical deserts; and cover, as with a carpet, the magnificent prairies of India and America, the wild haunt of the buffalo, or jealously hide the long-lost cities of Assyria, which once teemed with wealth, and myriads of human beings as busy as ourselves. Not only do they exist upon the surface of the soil, but their remains constitute a large part of the soil itself; so that *seeds, which subsequently germinated, have been thrown up from considerable depths, after having lain buried more than two*

* Dr. Noehden, F.L.S.

† Hunt's "Poetry of Science."

'My song to flowery gardens might extend,
To teach the vegetable arts to sing
The Pæstan roses and their double spring."—DRYDEN.

thousand years. The solid crust of the earth is, in part, of vegetable origin, as in the instance of the widely-spread coal-beds, with their remains of primeval forests. Moreover, the very air which covers the earth is not free from these objects; and the waters of the rivers and the seas abound in vegetable life.

956. *They offer the most wonderful diversities of features and proportions.* There are the varied flowers which, as the daisy and buttercup, form the nosegay of infancy and the garland of youth; as the sweet violet which, on its mossy bank, sheds perfumes on the loves of gentle maidens; as the blooming rose which adorns the bridal, and as the gloomy cypress which guards the tomb. There are the microscopic mould, which lends age to our mouldering ruins; and the gigantic forest-trees which, in the penal settlement of Norfolk Island, soar to the height of more than 200 feet; or the celebrated chestnut-tree of Mount Etna, which sheltered 100 horsemen.

957. *They exist of every age,* from the cell of the mushroom, which perishes in an hour, to the hoary Baobad of Senegal, which is computed to have lived since long before the days of Abraham. They quietly submit to the revolutions of centuries, with the changes of clime; and, as in the case of our own England, when the heat ceases to give life to cocoa-nut bearing palm-trees, and tree ferns, they gradually and silently appear as the modest primrose or the sturdy oak. They had traced long eras of the world's history when no human being marked their form; and they will, doubtless, bear testimony to the progress of events until time shall be no longer. *The antiquity of the blade of grass is far higher than that of the noblest families.*

958. They have done essential service to the animal kingdom, by having, directly or indirectly, fed all and clad many. They have formed the shelter of man and animals, and the chief part of the utensils and instruments of the former since his creation; and, even in our day, are presenting new treasures of infinite value for his use, as in the India-rubber and gutta-percha, so recently derived from their juices.*

959. Besides their uses to man and animals in general, they *clothe the surface of the soil,* thereby affording

* Orr's "Circle of the Sciences."

"Within the sun-lit forest,
Our roof the bright blue sky,
Where fountains flow and wild flowers blow,
We lift our hearts on high."—E. ELLIOTT.

protection to the smaller creatures, mitigating the arid effects of the sun, and preventing the disintegration of surface from the effects of the elements. They also tend to *preserve the purity of the atmosphere, absorbing the excess of carbonic acid, generated by the respiration of animals, and giving out by the decomposition of carbonic acid and water, a quantity of oxygen to replace that consumed by the animal kingdom.*

960. *Why are plants called organized bodies?*

Because they have a structure different from that of inorganic substances; a structure made up of *cells, fibres, tubes,* and *membranes,* which join together to form distinct parts and organs, and are acted upon by a *vital principle.*

961. *What course does the embryo plant take after the germination of the seed?*

It lengthens first *downwards,* next in an *upward* direction, thus forming a *centre or axis,* round which other parts are ultimately formed.

962. The term *axis of a plant* ought to be understood by every gardener. The root which strikes downwards in the direction of the earth's centre is called the *descending axis;* and the stem which shoots upwards in a contrary direction is the *ascending axis.* The point between the two is called the *crown* or *corolla.* Besides the stem and root, plants have a third movement, which acts *horizontally* and forms the *medullary system.* Thus, when the vital action of either *spore, embryo,* or *bud* is excited, the tissue developes in *three* directions: *upwards, downwards,* and *horizontally.*

963. *What is sap?*

Sap is, originally, *water holding in solution gaseous matter,* especially *carbonic acid,* together with certain *earths* and

"And, as the marble floors that are within,
Offend the eye, unless exactly clean;
So walks without, if not by labour kept
As clean, mowed often, often rolled and swept."—LAWRENCE.

salts, but as soon as it enters the stem it mingles with the vegetable mucilage which it finds there, and becomes denser than it was before; it is further changed by the decomposition of a part of its water, acquires a *saccharine character*, and rising upwards through the whole mass of wood, and more especially the *alburnum*, takes up any soluble matter it passes among. Its specific gravity keeps thus increasing till it reaches the summit of the branches; by degrees, it is wholly distributed among the leaves. In the leaves it is altered by the *carbonic acid* and *nitrogen* of the air, and then returned into the general system, more especially into the *fruit*, and the *bark*, through which it falls, passing off horizontally through the medullary rays into the interior of the stem, and *fixing itself in the interior of the bark*, especially of the root, when it undergoes various changes, the results of which are known under the name of *vegetable secretions*.

964. *What causes the flow of the sap?*

There have been various theories respecting the movement of the sap, but it is now pretty generally established that its flow arises from *the attraction of it by the leaves*, which continually diminish its quantity; hence the necessity that the sap extracted should be replaced by a further supply sent upwards from the roots.

965. *What is the immediate connection between the supply of sap and the growth of a plant?*

As the sap rises it fills the cells, and by supplying them with an excess of nutriment, *causes them to produce new cells*; and thus the plant grows, that is, increases in size *by the lengthening and widening of its cellular tissue*.

"Hence from the busy joy-resounding fields,
In cheerful errour, let us tread the maze
Of Autumn, unconfined; and taste, revived,
The breath of orchards big with bending fruit."—THOMSON.

966. *What purpose does the sap fulfil in first ascending and then descending?*

When the sap reaches the leaves, it is deprived by them of the gaseous matter which it contains, of its superabundant quantity of water, and of the substances which have become foreign or useless to nutrition. But while it thus loses part of the principles of which it was previously constituted, it undergoes a particular elaboration, *acquires new qualities, and thus becomes a fit nourishment for other parts of the plant.**

967. *What are the functions of the bark?*

It serves to *protect the young wood from injury*, and to act as *a filter through which the descending juices of a plant may pass horizontally into the stem, or downwards to the root.*

968. *Why are leaves of primary importance?*

Because they serve at once for *respiration, nutrition,* and *digestion.* If a plant is deprived of its leaves before the fruit has commenced ripening, the fruit will fall off without arriving at maturity; and a branch deprived of leaves for a whole summer, will either die, or fail to increase in size.

969. *Why do the odours of plants vary, both as regards the quantity and the manner of giving them out?*

The odour depends upon *volatile oils,* which are continually flying off, but in different degrees. Some odours are not perceptible till the plants are rubbed; some are most apparent in a recent state, and others in a dried state; in the latter case, the oil has been combined with too much

* Rhind's "Vegetable Kingdom."

"A sylvan scene, and as the ranks ascend
Shade above shade, a woody theatre
Of stateliest view."—MILTON.

water. In some plants, the oil is so rapidly dispersed in the day-time as to render its odour imperceptible, while, during night, it is eminently odoriferous. In general, plants in hot countries are more fragrant than those in cold countries; but their fragrance is so much dispersed by the heat as to be imperceptible in the day-time.

970. *What purpose does pith serve?*

It provides *nourishment for the young buds*, until they have acquired the power of procuring sustenance for themselves.*

971. *Why is the motion of the sap retarded or accelerated according to the scarcity or abundance of leaves?*

Because, ordinarily, the sap is carried to the top of trees, and its watery parts are then *perspired through the leaves;* but when the surface of the tree is greatly diminished by the loss of leaves, then, also, *the perspiration and motion of the sap is proportionally diminished;* and when the tree is abundantly clothed, the motion is accelerated in the same ratio.

972. *Why are trees filled with sap during winter, although the sap is not required for immediate nourishment?*

Because the root of a tree, as fast as it absorbs moisture from the earth, propels it into the hollow tubes of the stem; and as every particle of moisture thus absorbed, drives before it a corresponding volume of moisture previously existing, the tree becomes, in time, filled with sap almost

* We enter into a few only of the elementary principles of vegetation in this volume, the whole being fully considered and illustrated in "The Botanical and Horticultural Reason Why."

"Flowers, the sole luxury that nature knew,
In Eden's pure and spotless garden grew."—MRS. BARBAULD.

to bursting, until spring returns, *when leaves begin to form, and gradually empty the tubes of their superabundant supply.*

973. *Why are limpid drops often observed at sunrise, hanging at the points of leaves of grasses?*

Because, when the transpiration is not great, the water transpired by the leaves is absorbed by the air as it forms; but if the quantity of water increases, and the temperature of the atmosphere is low, the water is seen transpiring *in the form of extremely small drops*, which *often unite together*, and then acquire a considerable size.

974. *Why do leaves that have drooped during the day, frequently revive at night?*

Because transpiration is greatest between the hours of *six in the morning and twelve at noon*, and is least during the night; and when transpiration is too abundant, owing to excess of heat and drought, the plant becomes exhausted, and the leaves droop; but when this cause is removed, the plant revives, and the leaves regain their natural vitality.

975. *Why is the under side of the leaves of woody plants rougher than the surface?*

Because it is by the under side of leaves that transpiration takes place, and *the light down* which is apparent, *is favourable to this absorption.* While the upper surface, on the contrary, is smoother, and throws off the fluids which are useless for the nutrition of the plant.

976. It is certain that most leaves absorb moisture better by the one surface than the other; and it is known that some surfaces do naturally repel it, as may be seen on the leaves of the common

"Broad below,
Covered with ripening fruits, and swelling fast
Into the perfect year, the pregnant earth
And all her tribes rejoice."—THOMSON.

cabbage, after a fall of rain or dew, when it lies in globules upon them.

977. *Why should roots be permitted to extend in all directions?*

Because the elongation of the roots by their extremities, enables them to accommodate themselves to the soil, and allows the spongioles to extend freely without being injured. *The lateral extension of roots bear usually a relation to the horizontal spreading of the branches, so as to fix the plant more firmly,* and to allow fluid nutritive substances to reach the spongioles more easily. By restricting the roots, the growth of the plant is to a certain degree prevented.

978. *Why is the spiral arrangement of leaves conducive to vegetation?*

Because it *allows all of them to be equally exposed to the air and light,* and thus enables them to carry on their functions with vigour.

979. Although provision is thus made for the regular formation of leaf-buds, there are often great irregularities, in consequence of many being abortive, or remaining in a dormant state. Such buds are called *latent*, and are capable of being developed in cases where the terminal bud, or any of the branches, have been injured or destroyed. In some instances, as in firs, the latent buds form a regular system of alternation.

980. *Why do tendrils occur only on the upper part of vines?*

Because *the lower stem is strong, and needs no additional support*; but *the upper branches being soft, require aid to enable them to support the clusters of fruit;* they are, therefore, furnished with tendrils, which cling around

"Frail trees, like mortal men—all once must die;
'Tis fit a younger race their room supply,
For which ourselves but form the nursery."—LAWRENCE.

other plants or anything they can meet with, and thus give the support needed.

981. *What is alburnum?*

It is that part of the *wood* of the tree which is *last formed*, and is interposed between the bark and the perfectly-formed wood. It is called *alburnum* from its colourless character, not having yet deposited in it that colouring matter which imparts certain hues to the perfectly-formed wood.

982. *Why do the roots of plants and trees descend deeper into the earth, in proportion as the stem and branches ascend in the air?*

Because the increasing growth of the plant or tree requires *a larger amount of nourishment*, which the root satisfies by extending its powers of absorption; at the same time, the root, by descending more deeply, affords a *firmer* support to the plant or tree emanating from it.

983. *Why, when transplanting a root, is it better to carry it away with a ball of earth attached to it?*

Because this *protects the root from external injuries;* and also prevents those *derangements of the functions of the plant* which would inevitably ensue, if it were rudely torn from the earth, and suddenly transplanted to a soil physically and chemically different from that in which it originally germinated and grew: the plant will then continue to draw for aliment from its parent clod of earth, until the roots are enabled to pierce beyond such limit; and thus to become gradually inured to the change of nutriment presented by the surrounding soil.

"If I my friends, says he, should to you show
All the delights that in my garden grow,
'Tis likelier much that you would with me stay
Than 'tis that you should carry me away."—COWLEY.

984. *Why are plants most subject to blight during early spring?*

Beeause during that period, when branches and leaves first sprout forth, they are extremely succulent, and part with their water so readily, that during a dry easterly wind *this loss by evaporation cannot be supplied* with sufficient rapidity by the capillary vessels of the roots.

985. *Why do seeds require the exclusion of light while they germinate?*

Because light *exercises a powerful action on the carbonic acid* contained in the seed, by which its oxygen is withdrawn *too rapidly*, carbon fixed, the mass parched, and the possibility of healthful germination precluded.

986. *Why is distilled water unfitted as nourishment for plants?*

Because water when distilled, *parts with many substances necessary to vegetation;* among which may be reckoned *carbonic acid gas, hydrogen gas, humic acid, ammonia,* and a small portion of the *salts of lime and potass,* and these qualities are to be met with in their proper combination in the earth only.

987. *Why has nature adopted a variety of contrivances for the dispersion of seeds?*

Because if seeds were to fall into the soil *merely by dropping from the herb or tree,* then the great mass of them, instead of germinating and springing into distinct plants, would either *decay,* or *destroy their own species by overcrowding.*

988. Many fruits open when ripe by a sort of *sudden spring,*

"Approach, observe this perished gauze-like leaf,
Its delicate reticulation scan,
Know that each filament's a precious deed,
And was of life and beauty once the source."—T. L. MERRITT.

ejecting the seed with violence, and throwing it to some considerable distance from the plant. Many seeds are carried to a distance from their place of growth, merely by *attaching themselves to the bodies of animals* that may accidentally happen to come in contact with the plant in their search after food; the husks or hairs with which the pericarp, or fruit vessel, is often furnished, serving as the medium of attachment, till it is again accidentally displaced, and at last committed to the soil. *Cherries, sloes,* and other fruits, are often *carried off by birds* till they meet with some convenient place for devouring the pulpy pericarp, and then let the stone fall into the soil.

989. Some seeds are even *taken into the stomachs of the animals,* and afterwards deposited in the soil, or in a station favourable to their germination. Thus the seeds of the *mistletoe* are first swallowed by the thrush, and then deposited upon the boughs of such trees as it may happen to alight upon. Many seeds, by reason of their extreme minuteness, are calculated to be *conveyed to a distance by the winds;* such as the seeds of *mosses* and *fungi,* which evaporate from their cells like steam, and ascend like smoke or dust into the atmosphere, where they are borne about by the winds, till they have acquired a greater specific gravity than the medium in which they float, when they again descend, ready to spring up as plants wherever they may happen to alight, or meet with a suitable soil. Finally, a further means adopted by nature for the dispersion of the seeds of vegetables, is that of the instrumentality of *streams, rivers,* and *currents of the ocean.*

990. *Why is air necessary for the germination of seed?*

Because the action of air upon plants, at the first period of their development, presents the same circumstances as in the respiration of animals. It is the oxygen of air that, in the act of respiration, is the principal agent in giving blood the qualities which are to render it fitted for the development of the organs; and *the same oxygen aids and facilitates the germination of plants.* Seeds buried too deeply in the ground, and thus withdrawn from the action of atmospheric air, have been often removed for a

> "Lo! in the middle of the wood,
> The folded leaf is wooed from out the bud
> With winds upon the branch, and there
> Grows green and broad."—T

very long time without exhibiting any sign of life; but when, by some cause, they have been brought nearer the surface of the ground, so as to come in contact with the ambient air, their generation has been effected.*

991. *Why should especial care be taken of the first leaves that appear in the seed-bed?*

Because these leaves are the *sole organs of nourishment* of the young plant until it has acquired roots; therefore, if they be destroyed, or seriously impaired, the young plant must die.

992. *What occasions the knots or bunches with which the stems of plants and trees are frequently disfigured?*

They are a *species of tumour*, occasioned by some *obstruction in the channels of the sap*, by which the vessels become congested, and swell into a lump.

993. *Why is an abundant supply of water necessary for transplanted vegetables?*

Because, when vegetables are newly transplanted, the transpiration by the leaves is so great in proportion to the supply, as often to *exhaust and destroy the plants before the roots have so far recovered their action as to supply the waste.*

994. *Why do dry east winds require to be specially guarded against?*

Because they are apt to *absorb moisture from the leaves of plants* more rapidly than they are prepared to give it

* Rennie.

'These serve for useful ends: when frosts by night,
Or cold raw winds the tender blossoms bite;
Or mists by day, of poisonous nature, blight."—LAWRENCE.

out, and thereby deprive the plants of that portion of nourishment which it is absolutely necessary for their health and growth to retain.

995. *Why are tender plants best planted at the back of north or west walls?*

Because in such situations *sudden changes of temperature* cannot occur; and after a frost especially, the natural thawing must of necessity be very gradual, and therefore not destructive.

996. *Why are plants injured through being watered when a warm dry wind blows, or during bright sunshine?*

Because an inordinate degree of coldness is caused by *the water carrying off the heat* as it rises rapidly in the form of vapour into the air.

997. *Why should the leaves of delicate plants be carefully washed occasionally?*

Because *the pores of the leaves*, by which moisture and air are transmitted, *are exceedingly minute*, and liable to be *choked by exposure to dust.* Under these circumstances the functions of the plant are interrupted, and the plant itself deprived of nourishment.

998. *Why do plants which are called evergreen appear never to part with their foliage?*

Because, owing to the hardier nature of the plant itself, and the stronger nature of the leaves, the latter are retained longer than the ordinary term, and *time is thus allowed for new leaves to form, before the old ones have entirely fallen.*

"There to the porch belike with jasmine bound,
Or woodbine wreaths, a smoother path is wound."—WORDSWORTH.

999. *Why does the duration of life in a plant or tree depend mainly on the capability of the fibres of the roots to penetrate and travel through the earth?*

Because, in process of time, *that portion of the soil situated immediately about the root becomes exhausted* by the incessant demands that are made upon it to feed the plant above. When, therefore, the fibres of the roots penetrate into new soil, they are enabled to furnish a fresh supply of moisture to the root, and vegetation is by this means invigorated and kept alive.

1000. Roots being furnished with the power of perpetually *adding new living matter to their parts*, are thus enabled to pierce the solid earth in which they grow, to insinuate themselves between the most minute crevices, and to pass on from place to place as fast as the food in contact with them is consumed. *Thus plants, although not locomotive, like animals, do perpetually shift their mouths in search of fresh pasture,* although their bodies remain stationary.

1001. *Why should a tree be watered on that part of the soil corresponding with the end of its branches, and not close to the trunk?*

Because, *as the growth of the root corresponds with that of the branches,* the water being thus applied, will *find its way immediately to the absorbing fibres,* which are situated at the *extremities of the root.*

1002. *Why is paleness of colour in a plant an evidence of weakness?*

Because the lightness or depth of the *green colour* of plants is regulated *by the quantity of carbon* that mingles with the sap, and as it is to carbon that the vigour of a plant is chiefly indebted, *the darkness or lightness of the green shade becomes a test of strength or weakness.*

> "Come to the woodlands: Summer hath unfurled
> Her glowing banner to the drowsy wind;
> Come where broad boughs in twining arches meet,
> And flowers untroubled by the sultry heat,
> Delay our willing feet."—WESTLY GIBSON.

1003. *What is the primary purpose for which fruit is formed?*

For the protection and nutrition of the seed and germ, the maturation of which is essential to the propagation of the races of plants. In most cases, the whole of the fluid or nutritious part is consumed in effecting this end; but in certain instances, especially where it is developed by culture, there is a surplus, which, if unmixed with deleterious secretions, *becomes fit for animal food.*

1004. *Why is there sometimes on the same branch a sickly fruit, close to a perfect one?*

Because fruit has the power *of attracting food from the surrounding parts*, so that those which are more advanced in growth, or accidentally more vigorous, draw to themselves the food flowing to the weaker ones, which therefore deteriorate in proportion as their neighbours advance.

1005. *Why cannot those plants which are naturally the inhabitants of shady situations, endure exposure to the sun?*

Because the epidermis, or skin in which these plants are enveloped, is of that thin and porous nature, that it *allows the escape of water too freely* by perspiration under the solar stimulus, and thus accelerates the exhaustion of the plant.

1006. It should be borne in mind that the efficiency of leaves is considerably promoted by their being KEPT CLEAN; so much is this the case, that if the impurities which plants contract in cities are constantly washed off, they will grow equally well as in country places. This has been proved by the following experiments:—The petals of a peony took up five or six times more moisture, after being washed, than they did previously. The leaves of the *lilac, lily of the valley, ivy*, and *clematis*, about twice as much. It has also been ascertained that soap and water has much more cleansing eff

"The greenwood, the greenwood, what bosom but allows
The gladness of the charm that dwells in thy pleasant whispering boughs!
How often in this weary world, I pine and long to flee,
And lay me down, as I was wont, under the greenwood tree."—W. HOWITT.

than mere water; thus a *fig-leaf*, which had been lathered, absorbed 90 parts, while, after a mere water-bath, it took up only half the quantity; and a *bramble*, after soap and water, appeared to have absorbed 130 parts of water, could only consume 10 parts when cleaned with water alone. The explanation of this is, that *plants breathe by the leaves*, and, if their surface is clogged, the breathing is impeded or prevented. Plants perspire by their leaves, and dirt obstructs the perspiration; they feed by leaves, and dirt prevents their feeding.

1007. *Why are certain kinds of seeds capable of being kept a long time with their germinating powers unimpaired?*

Because, when the seed is ripe, it is dry, all the free water being parted with, and the interior occupied by starch or fixed oil, or some other such substance, together with earthy matters. *So long as these secretions remain undecomposed, so long does the vitality of the seed remain unimpaired.* The difference found in the duration of the growing powers of seeds probably depend principally upon differences in their chemical constitution. *Oily seeds*, which readily decompose, are among *the most perishable; starchy seeds*, which are least subject to change, are the *most tenacious of life.*

1008. *Why do the same causes that promote the germination of seeds, also hasten their death?*

Because seeds remain dormant *so long as the proportion of carbon peculiar to them is undiminished;* water is decomposed by their vital force; and it is believed that the *oxygen*, combining with *carbon*, forms *carbonic acid*, which is given off. The effect of access of water is, therefore, *to deprive seeds of their carbon;* and the effect of destroying their carbon, is to deprive them of the principal means which they possess of *preserving their vitality.*

"Paths, there were many,
Winding through palmy fern, and rushes fenny
And ivy banks."—KEATS.

1009. *Why is there generally an abundance of fruit in a season succeeding one of great scarcity?*

Because the destruction of fruit, when young, will *enable the leaves to deposit against a succeeding season, for the support of future fruit, all the organizable matter which the fruit destroyed would have otherwise consumed.*

1010. *Why are some plants enabled to vegetate without roots, on walls, rocks, &c.?*

Because the structure of their leaves is adapted for *absorbing*, but not *exhaling* fluids, and by this means vegetation is carried on independently of roots.

1011. In tropical climates the barest rocks become clothed with *lichens;* these, in decaying, afford footing for *mosses*, and these dying in their turn produce a portion of soil in which more perfect plants can strike out; and thus, by degrees, situations the most barren become clothed with verdure and flowers.

1012. *In what may we recognise a beautiful provision of Nature in respect to plants, in the periodical rise and fall of temperature?*

In the day when light is strongest, and its evaporating and decomposing powers most energetic, temperature rises, and stimulates the vitality of plants, so as to meet the demand thus made upon them; then, as light diminishes, and with it the necessity of excessive stimulus, temperature falls and reaches its minimum at night, the time when there is the least demand upon the vital force of vegetation; so that plants, like animals, *have their diurnal seasons of action and repose.*

1013. During the day the system of a plant is to a great extent exhausted of fluid by the watery exhalations which take place under the influence of sun-light; at night, when little or no perspiration

"To mute and to material things,
New life revolving Summer brings;
The genial call dead Nature hears,
And in her glory reappears."—SCOTT.

occurs, *the waste of the day is made good by the attraction of the roots, and by morning the system is again filled with liquid matter, ready to meet the demand to be made upon it on the ensuing day.* No plant will remain in a healthy state unless these conditions are fulfilled.*

1014. *What is the object of transplanting?*

It is chiefly to *increase by loosened soil their ramose roots,* by which it is found that the size and succulency of their leaves, flowers, and fruit, are increased. This applies to *herbaceous vegetables.* The object of transplanting *woody plants,* is to increase the number of *fibrous roots,* so as to prepare young subjects for successful removal to their final destination.

1015. *At no period can the operation be performed if the plants are growing.* Even if the buds are only "pushing," the process should be avoided, because, immediately after that period, the demand upon the roots is greatest; for, although in consequence of the smallness of the surface of the young leaves, the action of perspiration may seem to be feeble, yet the thinness of the newly-formed tissue will not enable it to resist the drying action of the atmosphere, unless there is a most abundant afflux of sap from the roots. *Transplanting from garden-pots,* in which the roots are *preserved artificially* from injury, may be performed equally well at any time if care is taken.†

1016. *What is the origin of buds?*

Various opinions have been entertained upon this interesting subject. Some persons have held them to be formed from the *pith,* or *cellular tissue;* others that they arise from *pre-organized germs* existing in the sap; others that they are generated from the *vessels of the inner bark;* but the most recent and probable theory is, *that all buds protruded from the surface of a plant, at whatever period of its growth, have been originally formed at the centre of the stem*

* Loudon's "Encyclopædia of Gardening."
† Dr. Lindley's "Theory of Horticulture."

> "The woodbine trees red berries bear,
> That clustering hang upon the bower,
> While, fondly lingering here and there,
> Peeps out a dwindling sickly flower."—CLARE.

or branch on which they appear; that is, on the original annual shoot; and have been pushed outwards horizontally through every additional layer of alburnum, while yet in a soft state, though it requires some peculiar excitement to protrude them into shoots, which may not occur till after a period of many years.

1017. The bud is represented as leaving in its progress outwards a pale streak of *parenchyma,* indicating its path, which is very perceptible in a transverse section of the *willow,* taken near the protrusion of a young shoot. This theory can only apply to woody plants, which have their diameters augmented by the addition of annual and concentric layers.*

1018. *The true import of the formation of sprouts* upon the vegetable stock is that of a subordinate propagation. The cycle of development, given by the sexual propagation (formation of seed) divides again, in the majority of plants, in the most varied manner, into subordinate series of development, which proceed out of one another by the formation of sprouts; so that what in more highly-individualised beings is completed in the simple individual, is distributed in the plant, through the interposition of a subordinate process of propagation, among a society of individuals, a developmental series, and a family circle formed thereby.†

1019. *What is the object of budding?*

The object is almost identical with that of *grafting.* It consists of taking "an eye" or bud attached to a portion of the bark, of different sizes and forms, and transporting it to a place in another, on a different ligneous vegetable. It affords a means of *rendering the barren branches of trees fruitful,* by the transfer of buds from trees where they may be too numerous.

* Rev. P. Keith, "On the Origin of Buds." Linnæan Transactions.
† Dr. A. Braun's "Botanical Memoirs."

"All leading pleasantly
To a wide lawn, whence one could only see
Stems thronging all around between the swell
Of turf and slanting branches."—KEATS.

1020. Budded trees are generally two years later in producing their fruit than grafted ones; but the advantage of budding is, that where a tree is rare, *a new plant can be got from every three or four eyes.* There are also trees which propagate much more readily by budding than by grafting; and others, as most of the stone fruits, are apt to throw out gum when grafted. When grafting has been omitted, or has failed in the spring, budding comes in as an auxiliary in the summer.*

1021. *The first thing to be done* is, to select a young shoot of the current year, from which the bud is to be taken, and a stock of one or of several years' growth, into which the bud is to be inserted. The bud is cut out with a portion of the bark and the wood attached

above and below the footstalk of a leaf, in the axil of which leaf the bud is situated. To do this a sharp penknife or budding knife is inserted in the shoot, about three-fourths of an inch below the bud, and passed up beneath the bud to about half an inch above it; the bud, with the bark and wood to which it is attached, is then held in the left hand, and with the knife in the right hand the thin film of wood is quickly picked out, leaving the bud attached—technically called the shield. A shield is then formed in the back of the stock, about a third of an inch in length; and a transverse cut is made within one-fourth of an inch of the upper part of the longitudinal slit. The bark is opened on both sides of the longitudinal slit by means of a thin flat piece of bone or ivory; or, in nursery practice, with the end of the handle of the knife, which is made thin on purpose. The bud is now inserted in its natural position, with the bud bearing upwards, and a portion of the upper part of the bark, to which the bud is attached, is

* Loudon's "Encyclopædia of Gardening."

'Yes, prattlers, yes. The daisy's flower
Again shall paint your summer bower;
Again the hawthorn shall supply
The garlands you delight to tie."—SCOTT.

cut across, so as to fit to the transverse cut which was formed in the stock. The bud is made fast in its situation by tying it with a strand or ribbon of bast matting; this being done in summer or autumn, the matting remains on for a month or six weeks, according to circumstances, till the back of the bud shows by its healthy appearance that a vital union has taken place. The matting may then be loosened, and in a week or two altogether removed.

1022. *Shield budding reversed* is performed by paring the transverse cut at the bottom of the perpendicular slit instead of at the top; and its most important use is to induce a state of productiveness in fruit trees; this mode is preferred by those who think that the sap rises in the bark equally with the wood—a principle which some are disposed to question. It is, however, generally admitted to be the best method for trees having gummy sap.

1023. *Niche budding* is when the wood is retained in the bud. In placing the bud on the stock, the principal thing to be attended to is, to bring the horizontal edges of the base of the niche in the stock, and those of the bud, which is to fit into it, into the most perfect contact possible; because the union is produced, not as in common summer budding, by the junction of the soft wood of the stock with the rudiment of the soft wood on the inside of the bark of the bud, but by the junction of soft wood with soft wood. This mode of budding will always succeed best when the niche in the stock is made where there is already a bud, making the horizontal cut through the base of the bud.

1024. *Annular or ring budding* is performed by joining the stock and scion together, as shown in the engraving, but in either case the top of the stock is not to be interfered with. This is a valuable mode of propagating trees or shrubs with hard wood and thick bark, or those which, like the walnut, have buds so large as to render it difficult to bud them in the common way. There are many other kinds of budding, but these are the most general in use.

"Then comes the tulip race, where beauty plays
Her idle freaks. The exulting florist marks
With secret pride the wonder of his hand."—THOMSON.

1025. *It sometimes happens in the case of roses,* that the bud will produce a shoot the same season in which it has been inserted, but it more frequently remains dormant till the following spring; at this period the stock should be cut three or four inches above the bud; and the shoot, as it grows, should be slightly tied to the portion of the stock left on above the bud, in order to prevent its being injured by high winds. The second year this portion of the stock may be cut off close to the bud. Buds may be inserted in stocks at a few inches from the ground, in which case the plants produced are called dwarfs; or in straight stems at four, five, or six feet from the ground, when the plants produced are called standards. The latter is the most common mode of budding roses and orange trees; but other shrubs and trees of rare or ornamental kinds are commonly budded within a foot, or a few inches from the ground. Sometimes, buds of several kinds are inserted in the same stock, and sometimes buds are inserted in branches in different parts of the tree, for the sake either of supplying vacant places in the branches, or of producing several kinds on the same tree. In all cases of budding, it is essential that the stock shall not be very different from the bud to be inserted in it. In some cases it is even necessary that the bud and the stock should be of the same species; while, on the other hand, it sometimes happens that a bud may be inserted successfully in any stock which is of the same natural order.*

1026. *Why do circumcised, or ringed branches of fruit-trees produce abundant blossom, and early maturity?*

Because, when the course of *the descending sap is intercepted,* it accumulates above the ringed space; whence it is *repulsed and carried forwards to where it is expended in an increased production of blossoms and fruit.*

1027. The part of the branch which is below the

* "Dictionary of Daily Wants."

'Not fairer grows the lily of the vale,
Whose bosom opens to the vernal gale."—FALCONER.

decorticated space, is ill supplied with nutriment, and ceases almost to grow; it in consequence operates less actively in impelling the ascending current of sap, which must also be impeded in its progress through the decorticated space. The parts which are above it must therefore be less abundantly supplied with moisture; and drought, in such cases, always operates very powerfully in accelerating maturity. *When the branch is small*, or *the space from which the bark has been taken off is considerable*, it almost always operates *in excess*; a morbid state of early maturity is induced, and the fruit is worthless.

1028. If this view of the effects of partial *decortication*, or *ringing*, be a just one, it follows that much of the success of the operation must be dependent upon the selection of proper seasons, and upon the mode of performing it being well adapted to the object of the operator. If that be the production of blossoms, or the means of making the blossoms set more freely, the ring of bark should be taken off *early in the summer* preceding the period at which blossoms are required: but if the enlargement, and more early maturity of the fruit, be the object, the operation should be delayed *till the bark will readily part from the alburnum in the spring*. The breadth of the decorticated space must be *adapted to the size of the branch*; but I have never witnessed any except injurious effects, whenever the experiment has been made upon very small, or very young branches; for such become debilitated, and sickly, long before the fruit can acquire a proper state of maturity. I have found a tight ligature, applied in the preceding summer, in such cases to answer, in a great measure, all the purposes of ringing, with far less injurious consequences to the tree; and if such were applied to the stems, or principal branches of *cherry-trees*, which are to be forced very early in the following year, I believe the blossoms would be found to set more freely, and the fruit to attain an early maturity. I have also succeeded in preserving, to a great extent, the health of a ringed branch by instantly covering the exposed surface of the alburnum with a tight bandage of coarse thread coated with beeswax, if the branch were small, or of fine pack-thread, if it were large; so as wholly to fill the space from which the bark had

> " What is weak,
> Distempered, or has lost prolific powers,
> Impaired by age, the unrelenting hand
> Dooms to the knife."—COWPER.

been taken. By such means the desiccation and consequent death of the external surface of the alburnum have been prevented; and I, consequently, think it not improbable that the operation might be performed with advantage to the cherry-tree, and some other fruit trees, to which it has hitherto been found destructive.*

1029. *Ringing is an excellent method for making layers of hard-wooded plants strike root with greater certainty*, and in a smaller space of time than is attained in any other way. The accumulated vegetable matter in the callus, which is formed on the upper edge of the ring, when brought into contact with the soil, or any material calculated to excite vegetation, readily breaks into fibres and roots. *By this means cuttings may be rendered more tractable for propagation.* If a ring be made on the shoot which is to furnish the cutting, a callus will be created, which, if inserted in the ground after the cutting is taken off, will freely emit roots. A ligature would perhaps operate in a similar manner, though not so efficiently; it should tightly encircle the shoot destined for a cutting, and the latter should be taken off when an accumulation of sap has apparently been produced. The amputation in the case of a ligature, as well as in that of the ring, must be made below the circles, and the cutting must be so planted as to have the callus covered with earth.†

1030. *What is the object of grafting?*

To preserve and multiply varieties and sub-varieties of fruit trees; endowed accidentally or otherwise with particular qualities, which *cannot be with certainty transferred to their offspring by seeds*, and which would be multiplied *too slowly*, or *ineffectually*, by any other mode of propagation.

1031. To *accelerate the fructification* of trees, barren as well as fruit-bearing: for example, suppose two acorns of a new oak, received from a distant country; sow both, and after they have grown one or two years, cut one of them over, and graft the part cut off on a common oak of five or

* T. A. Knight, Esq., F.R.S. † Mr. Hempel.

> "He held a basket full
> Of all sweet herbs that searching eye could cull;
> Wild thyme and valley—lilies whiter still
> Than Leda's love."—KEATS.

six years' growth: the consequence will be, that the whole nourishment of this young tree of five or six years' growth being directed towards nourishing the young scion of one or two years, *it will grow much faster and consequently arrive at perfection much sooner, than its fellow, or its own root left in the ground.*

1032. The third use of grafting is, *to improve the quality of fruits;* the fourth, to *perpetuate varieties of ornamental trees and shrubs; and the fifth, to change the sorts of fruit on any one tree, and renew its fruitfulness.**

1033. The objects of these operations are manifold. Many plants, such as the *pear* and *apple,* will *bud or graft freely,* but are *difficult to strike from cuttings.* Species which are naturally delicate become robust when "worked" on robust stocks; and the consequence is a more abundant production of flowers and fruit: thus the more delicate kinds of *vines* produce larger and finer grapes when worked upon such coarse robust sorts as the *Syrian* and *Nice.* The *double yellow rose,* which so seldom opens its flowers, and which will not grow at all in many situations, blossoms abundantly, and grows freely, when worked upon the common *China rose.* The peculiarities of some plants *can only be preserved by working;* this is especially the case with certain kinds of *variegated roses,* which *retain their gay markings when budded, but become plain if on their own bottom.*†

1034. *The most common application of grafting,* is the propagation of valuable orchard fruits, the grafts or scions of which are made to grow upon worthless varieties. This operation is performed in the spring, just when the sap begins to run. A young healthy branch is selected from the plant to be propagated, and divided into lengths or scions, each of which bears about three or four well-formed buds; the lower end of the scion is cut in a sloping manner, to the extent of an inch and a half or two inches, and an oblique incision is made in the cut so as to form a "tongue." The plant to be

* Loudon's "Encyclopædia of Gardening." † Dr. Lindley.

"From the soft wing of vernal breezes shed
Anemonies: Auriculas enriched
With shining meal o'er all the velvet leaves,
And full Ranunculas of glowing red."—THOMSON.

operated upon, called the "stock," has next a branch, of the same diameter, if possible, as the scion, cut back to the firm sound wood, and then shaved obliquely upwards, till it presents a face of the same dimensions and form as that of the scion; on that face an incision is made obliquely downwards, to receive the tongue of the scion. The two are then fitted together, care being taken that the divided bark of the scion is exactly adapted to the divided bark of the stock; the two are bound firmly together with bark or worsted; the bandage is carefully covered with well-tempered clay, in order to keep the parts damp and to exclude air from the wound; and the operation is finally left to nature, with this precaution, that any buds from the stock below the scion are removed as soon as they begin to sprout. In about six weeks or two months the young scion will have made growth, the union is then effected, and the ligature, as well as the clay, may be removed, care being still taken that the scion is not blown off the stock by the winds. Such is the general nature of the operation in its most common form; but it may be varied in many ways, of which the following are the chief.

1035. *Whip-grafting* is the most common mode, and is especially to be recommended when the stock and the scion are of the same size. The head of the stock is pruned off at the desired height, and then a slip of bark and wood removed at the upper portion of the stock, with a very clean cut, to fit exactly with the corresponding cut which must be made in the scion. A very small amount of wood must be cut away and the surface made quite smooth. Care must be taken that no dirt lodges upon the cuts. A sloping cut must now be made in the scion corresponding with that on the stock, and a slit made to fit in a cleft made in the stock when heading it. Care must be taken that the scion fits bark to bark, on one side at least. Where the stock and the scion differ in point of size, of course only one side can touch, and great care should be taken in this part of the operation; and in the case of a young scion on an old tree, some allowance must be made for the ruggedness of the bark. The scion

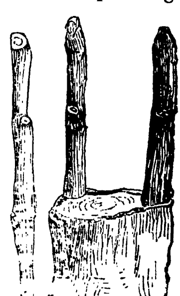
> "A master's hand disposing well
> The gay diversities of leaf and flower,
> Must lend its aid to illustrate their charms,
> And dress the regular yet various scene."—COWPER.

being thus adjusted, the whole is bound close, but not too tightly, with a shred of matting, care being taken that the inner barks coincide. The clay is now applied, in order to keep the parts moist.

1036. *Saddle grafting* is practised only where the stock is of moderate dimensions. The stock is cut into a wedge-like form, and the scion slit up the middle, so adapted that it shall be seated across or ride upon the former. The advantage of this mode consists offering the largest surface for the junction of the scion and stock, but, as in whip-grafting, the bark must, at least on one side, be neatly fitted to the bark on the other.

1037. *Cleft-grafting:* in this operation a cleft or division is made in the stock to receive the scion, which is cut like a wedge; again taking care, in case of irregularity of size, to make one side fit bark to bark. The process of tying and claying, goes on in the usual manner, with this exception, that a small hole is left in the clay opposite the bud of the scion, to allow that bud to develope itself freely. When the scion has grown fourteen or fifteen days, it is then headed back to one bud, which is left to draw up the sap until the union has fairly taken place between the stock and the scion.

1038. *Crown grafting* is merely a variety of cleft grafting. It is practised upon old trees, either for their total renewal, or upon large amputated branches, to renew by degrees. It is, upon the whole, a better mode than cleft grafting, because the stock, if old, is not subjected to the chance of being split; the scions in this case being placed between the bark and the wood, as in the engraving. In this kind of grafting, great care must be taken that the bark of the stock be not bruised during the process of opening the bark for the reception of the scion, and for this purpose a proper grafting knife should be used.



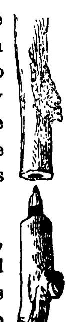
1039. *Shoulder grafting* is not frequently resorted to in England, there being little occasion for its practice.

> "There, as in shade and solitude I wander
> Thro' the green aisles, or, stretched upon the sod
> Awed by the silence reverently ponder
> The ways of God."—H. SMITH.

When the stock and scion are equal in size, however, it offers an opportunity of gaining the advantage of an extra amount of alburnous union, as explained by the accompanying illustration.

1040. *Side grafting* is, in general, performed on a stock, the head of which is not cut off, or on a branch without its being shortened. The great utility of this mode is the facility it offers of supplying branches to parts of trees where they may have become too thin, or making a branch in case of accidents. It is well adapted for the insertion of new kinds of pears, or other fruits, on established trees, in order to increase the collection, or hasten fruit-bearing. It is also usefully employed upon wall or espalier trees that have become naked of fruit-buds towards the centre, while they may have abundance towards their extremities.

1041. *Peg grafting* is one of the oldest varieties of this mode of propagation, although now seldom used. The stock is cut over horizontally at the desired height, and a hole is drilled in the centre to receive the end of the scion; this hole must be in proportion to the size of the tree to be operated upon; if for a small tree or plant, a $\frac{1}{4}$-inch gimlet will be sufficient; but for one of larger dimensions and spreading head an auger of two or three inches may be used. The depth to which this perforation should be made, must be determined by the size of the scion. The scion should also be of the same diameter with the stock, and so fashioned that a portion of its lower end is reduced, leaving only so much of the centre as will form a peg, to fit exactly into the perforation. When the scion is thus fitted on the top of the stock, the graft or top of the tree is supported firmly in its upright position by props, to secure it against winds, &c.



1042. In the various processes of grafting here explained, the following main principles have a general application, and should be kept steadily in view: 1. Cuttings intended for scions should be taken from the trees before the movement of the sap commences in spring, and put in moderately moist earth or sand, in a shady situation. If the stocks be cut down at the same time it will be

"A mighty forest: for the moist earth fed
So plenteously all weed-hidden roots
Into o'er-hanging boughs and precious fruits."—KEATS.

so much the better; any large limbs of trees which it may be found necessary to graft, should by all means be cut in before vegetation becomes active, otherwise extravasation takes place, and canker is in consequence induced. 2. In bringing together the scion and stock, the bark of one should be united with the greatest nicety to the bark of the other. 3. All the processes should be performed with a very clean and exceedingly sharp knife, taking care that nothing, such as dirt or chips, intrude itself between the scion and the stock. 4. Apply the bandage equally and firmly; not so tightly as to cut or bruise the bark. The best ligature is formed by broad strips of bast matting. 5. In selecting grafts, be careful in the choice of wood, avoiding, on the one hand, exhausted or badly barked scions, and on the other, the immature watery spray, which frequently springs from the old trunks of exhausted or diseased trees.

1043. *What is the object of pruning?*

It seeks to *render trees more fruitful*, to make them *grow higher*, and with *greater regularity*, and to *produce larger and better fruit.*

1044. *If carried to too great an extent*, the desired result is not obtained, for every tree requires a certain amount of *leaf-surface* for the elaboration of its sap; and, therefore, if this be reduced too much, blossom-buds are produced less abundantly, for leaves are more necessary for the health of the plant; and, by a wise provision, the parts less requisite for individual vigour are superseded by the parts more needed. On the other hand, if the branches are left too thick, they over-shadow those beneath them, and so exclude the light as to prevent that elaboration of the sap, without which no blossom-buds are formed, but an excessive production of leaves, in the vain effort to attain by an enlarged surface that elaboration which a smaller surface would effect in a more intense light.

1045. *The season of pruning* must be regulated in some degree by the strength of the tree; for although, as a general rule, the operation should not take place till the fall of the leaf indicates that vegetation has ceased, yet, if the tree be weak, it may often be performed with advantage a little earlier; but still so late in the autumn as to prevent the protrusion of fresh shoots.

> "Who can, unpitying, see the flowery race,
> Shed by the morn, their new-flushed blooms resign
> Before the parching beam?"—THOMSON.

1046. *The chief guide in pruning* consists in being well acquainted with the mode of the bearing of the different sorts of trees, and forming an early judgment of the future events of shoots and branches, and many other circumstances for which some general rules may be given; but there are particular instances which cannot be judged of but upon the spot, and depend chiefly on practice and observation. Summer pruning is a most necessary operation. Young shoots require thinning to preserve the beauty of the trees and to encourage the fruit; and the sooner it is performed the better. It is, therefore, advisable to begin this work in May, or early in June, removing all superfluous growths and ill-placed shoots, which may be done with considerably more expedition and exactness than when the trees have shot a considerable length.

1047. *When a tree is inclined to luxuriance,* it is proper to retain as many of the regular shoots as can be commodiously trained in with any regularity, in order to divide and exhaust the too abundant sap. It will be necessary to review the trees occasionally, in order to re-form such branches or shoots as may have started from their places or taken a wrong direction; and, according as any fresh irregular shoots protrude after the general dressing may be displaced, or as the already trained ones advance in length, or project from the wall or espalier, they should be trained in close. In the winter-pruning, a general regulation must be observed, both of the mother branches, and the supply of young wood laid in the preceding summer; and the proper time for this work is any period

Fig. 1.

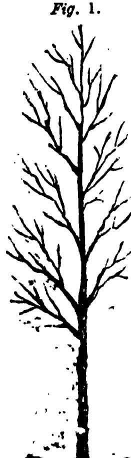
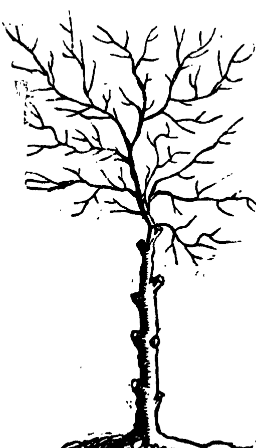


Fig. 2.



"Who loves a garden, loves a greenhouse too,
Unconscious of a less propitious clime;
There blooms exotic beauty warm and snug."—COWPER.

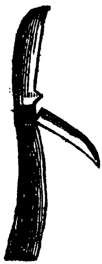
during open weather, from November till March; but the sooner the better. In performing this work, it is proper to un-nail or loosen a chief part of the branches, particularly of peaches, nectarines, apricots, vines, and other trees requiring an annual supply of young wood. The effects of judicious and injudicious pruning are illustrated by the accompanying engravings. *Fig.* 1 represents a tree of thirty years' growth, which has been regularly and properly pruned. *Fig.* 2, a tree of the same age, which has been neglected as to pruning during its early growth, and has now been pruned in a way too frequently practised, namely, by sawing and lopping off the branches after they have attained a large size. *Fig.* 3 shows the bad consequences of neglecting early pruning in the case of a plank cut from an ash tree, which has been pruned by lopping off the large branches for many years before it was felled. The cuts in this case had been made several inches from the bole, and the branches left being very large, the stumps had become rotten. The enlargement of the trunk had not, however, been stopped, for the new wood had covered over all the haggled parts, in some places to several inches thick. Yet the effects of the previous exposure to the action of the weather, by injudicious pruning, is strikingly marked by the decayed state of the parts connected with branches which had been amputated. From this it will clearly appear that, if pruning is to be practised on deciduous trees at all, it should be commenced while they are young, and carried on progressively; and if so, no such blemishes will be found in the timber when cut up. Yet it does sometimes happen that young plantations under twenty years' growth are to be pruned. In such cases, when the ill-placed branches, or those intended to be removed, exceed in diameter two inches, it is better to commence at their extremities and shorten them back yearly. By thus cutting off their supplies, the base of the branch will be lessened more and more of its nourishment; it will become sickly, and ultimately die away altogether.

Fig. 3.

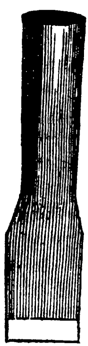
1048. *The implements employed for pruning* are various; the following will be found the most useful, and with them every operation of pruning may be advantageously accomplished. Of

> "But God alone when first His active hand
> Imprints the secret bias of the soil;
> He, mighty parent! wise and just in all,
> Reveals the charms of Nature."—AKENSIDE.

pruning knives, a small pocket pruner having two blades, the one larger



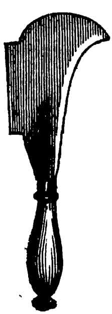
than the other, is to be recommended for general use. Its merits consist in its lightness and small bulk, as well as its being useful for pruning, making cuttings, and cutting flowers. Pruning chisels are nearly as various as pruning knives. The best, however, are in shape of a carpenter's chisel, but with a handle of greater or less length and strength, according to the height and size of the branch to be amputated. They vary in breadth of cutting face from one to three inches, and are wrought by placing the face of the chisel upon the part of the branch where the cut is to be made, and being held there by one man, while another with a wooden mallet, striking upwards, drives the chisel through the branch.



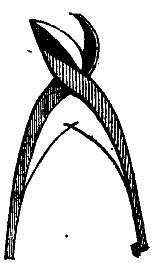
Thus, branches of almost any size, from seven to twenty feet from the ground, may be cut off. Branches nearer the ground may be cut off with chisels having shorter handles, as shown in the engraving. Another modification of it is sometimes used in orchard and ornamental tree pruning, differing only from the former in having a guard or plate placed behind the blade, to prevent it entering too far into the trunk from which the branch is to be removed. The advantage of the pruning chisel in all cases over the pruning saw, is its saving the trouble of ascending the tree, and the damage that may be done to the branches by a man going up to cut off the branch. An excellent substitute for all pruning chisels is found in the American or Indian pole-saw, depicted in the annexed figure. This has a blade about four inches broad, and from eighteen inches to two feet in length, fixed to a pole-handle of any required length, so as to reach the branch to be removed. This saw differs from the ordinar implement, in operating by pulling instead of thrusting, so that a person standing on the ground can work the saw to every advantage, while it is sufficiently stiff not to break while passing through the wood. The cuts made by a saw should have the wound smoothed by the knife or small plane, and in

"While Summer laughing comes, and bids the months
Crown his prime season with their choicest stores;
Fresh roses opening to the solar ray,
And fruits slow-swelling on the loaded bough."—MALLET.

most cases be painted over with some mild paint to exclude the air and moisture. The pruning bill is a species of large knife, and in the hands of an expert workman is valuable, in cutting off branches larger than the pruning knife could sever. The stroke should always be given in an upright direction, and, if possible, one blow should perform the operation. They are very useful in pruning thick and overgrown shrubbery, as they can be wrought with greater effect in thick jungles than almost any other cutting implement. Sometimes they have only one cutting face, and that is in general somewhat crooked towards the point; at other times they have an axe-like face of several inches in length upon their back, useful in cutting large branches; and at others they have, instead of a cutting face upon their back, a set of teeth or serratures, by which the operation of sawing may be performed. Pruning shears are of a still greater variety; one of the smallest of the kind, and particularly useful for pruning off tender



shoots is seen in the accompanying figure. It may also be used for cutting off leaves, bunches of grapes, flowers, &c., that may not be readily reached by the hand; and while it severs the leaf and stem, still holds the thing severed until it may be taken in hand. The curve passing round the handle and lever in the form of a ring, when pulled downwards by the cord, draws the leaves towards the handle, and causes the shear-like faces to meet; these, instead of being sharp at their edges, meet in what may be called the half-check form, bruising rather than cutting asunder the footstalk of the flower or leaf, and thus preventing its falling. The stud above the ring prevents it from slipping upwards, and the spring between the lever and handle keeps the shears open until acted upon by the cord.*



1049. *Why should fruit-trees be trained, wherever practicable?*

Because this system induces a *disposition to form*

* "Dictionary of Daily Wants."

"Two leaves produced, two rough indented leaves,
Cautious he pinches from the second stalk
A pimple that portends a future sprout,
And interdicts its growth."—COWPER.

flower-buds in rare and tender trees or plants; it *matures and improves the quality of fruits* which would not otherwise ripen in the open air. By the regular spreading of the branches the *leaves are more fully exposed to the sun* than they can be on any standard, and by the form of training, *the motion of the sap being retarded, induces a preternatural tendency to form buds.* Besides these advantages, the trees when placed in favourable situations, are *sheltered from cold winds, and receive warmth from the wall,* or other support to which they are attached.

1050. *Why does the manner in which fruit-trees are trained considerably affect their produce?*

Because they are *deprived of the motion which their branches naturally receive from the winds;* the form in which they are trained, therefore, operates powerfully upon their permanent health and vigour.

1051. The rule to be observed in training, should be to expose as large a surface of the leaves as possible to the light, without placing any of them so as to shade others; the young wood will thereby acquire the most perfect maturity, and will afford abundant and regular blossom.*

1052. Espaliers are generally formed of upright and cross-bars of wood, but sometimes made of cast-iron. The best are of wood, and from four to five feet in height. To these the trees are trained as on a wall, with this difference, that instead of being nailed, the branches are usually tied; the fastenings are soft hemp cord or strips of bast, but twigs of willow answer much better.

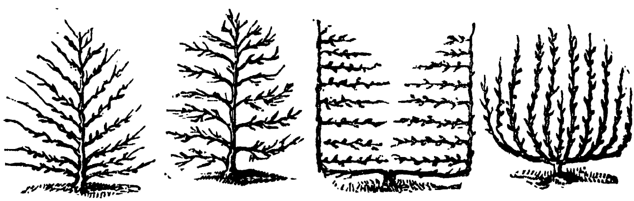
1053. *The situation of espaliers* is generally along the side walks; and if the trees be carefully trained, they have a neat effect. Care must be taken that they do not prevent the sun and air from reaching the surrounding vegetation.

* T. A. Knight, Esq., F.R.S.

'But were not Nature still endowed at large
With all which life requires, though unadorned
With such enchantment; wherefore, then, her form
So exquisitely fair?"—AKENSIDE.

1054. *The following is the plan of cultivation:* Have the ground well trenched and manured, and plant the trees three or four feet from the walk, and twice as near to one another as they should afterwards be when full-grown. The reasons for close planting are, that the value of a few crops is more than the expense of the trees; the rails are sooner covered, and when the trees begin to meet and incommode one another, you can then, having ascertained their various qualities, give scope to the best, by diminishing or rooting out the less worthy.

1055. *To incur no more expense than is necessary,* the stakes may be placed two feet apart, in which case the annual shoots will require to



be conducted from one resting-place to another, by pieces of bast or wild briar, or willow of two years' growth. These conductors require a firm and separate tying, distinct from that which fastens more loosely the living wood; they thus give strength to the rails and provide for straighter training than is commonly done by having the stakes twice as thickly set, and consequently at double the expense of timbers. Espaliers may be trained in a great variety of forms, those represented in the engravings being the best adapted for general purposes.*

1056. *Why should cuttings be placed under hand glasses, or in hotbeds?*

Because they will more readily strike when shaded from the light, and kept warm and moist. *Light has a tendency to draw the sap towards the leaves and thus to prevent its being employed in throwing out roots.*

* "Dictionary of Daily Wants."

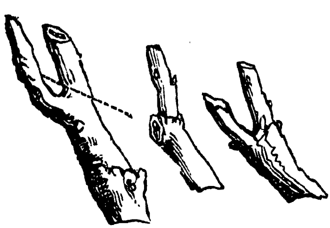
"Here are thy walks, O sacred Health!
The monarch's bliss, the beggar's wealth;
The seasoning of all good below!
The sovereign friend in joy or woe!"—MALLET.

1057. *Propagation by cuttings* is a mode of culture requiring some delicacy and discrimination. It may be considered, as to the choice of cuttings, their preparation, their insertion in the soil, and their future management.

1058. The *choice of cuttings* should be directed first towards those branches of trees and shrubs which are thrown out nearest the ground, and especially such as recline, or nearly so, on the earth's surface, as these have always the greatest tendency to produce roots.

1059. The *proper time for taking cuttings* from the mother plant is when the sap is in full motion, in order that in returning by the bark it may form a callus or protruding ring of granular substance between the bark and wood, whence the roots proceed. As this callus, or ring of spongy matter, is generally best formed in ripened wood, the cutting, when taken from the mother plant, should contain a part of the former year; or, in plants which grow twice a year, of the wood of the former growth; or in the case of plants which are continually growing, such wood as has begun to ripen or assume a brownish colour.

1060. The *preparation of the cutting* depends on, or is guided by, this principle—that the power of protruding buds or roots resides chiefly, and in most cases entirely, at what are called joints, or at those parts where leaves or buds already exist. Hence it is, that cuttings ought always to be cut across with the smoothest and soundest section possible at an eye or joint.



1061. It is a common practice to cut off the whole or a part of the leaves of cuttings; but the former is always *attended with bad effects*, as the leaves may be said to supply nourishment to the cutting, till it can sustain itself.

1062. The *insertion of cuttings* may seem an easy matter, and none but a practical cultivator would imagine that there could be any difference in the growth between cuttings inserted in the middle of a pot, and those inserted at its sides; yet some sorts of plants if

"Few self-supported flowers endure the wind
Uninjured, but expect the upholding aid
Of the smooth-shaven prop."—COWPER.

inserted in a mere mass of earth, will hardly, if at all, throw out roots; while, if they are inserted in sand, or in each of the sides of the pots, so as to touch the pot in their whole length, they seldom fail of becoming rooted plants. The art is to place them so as to touch the bottom of the pot, and afterwards plunge them in a bank or hotbed, and keep them moist.

1063. The *management* of cuttings requires that they should not be planted too deep, though such as are large ought to be planted deeper than such as are small. Too much light, air, water, heat, or cold, are alike injurious. To guard against these extremes in tender sorts, they should be nurtured beneath a hand or bell-glass. Immersing the pot in earth (if the cuttings are in pots), has a tendency to preserve a steady uniform degree of moisture at the roots; and shading or planting the cuttings, if in the open air, in a steady situation, prevents the bad effects of excess of light. The only method of regulating the heat is double or single coverings of glass or mats, or both. A hand-glass placed over a bell-glass will preserve, in a shady situation, a very constant degree of heat.

1064. *Piping is a mode of propagation similar to that of cuttings.* This is effected by separating a shoot from a part of the stem, where it is nearly or somewhat ripened. The root end of the plant must be held between the finger and thumb of one hand, below a pair of leaves, and with the other pull the top part above the pair of leaves, so as to separate it from the root part of the stem. These pipings, or separated parts, are inserted without any further preparation in finely-sifted earth to the depth of the first joint or pipe, gently firmed with a small dibber; then watered, a hand-glass put over them, and their future management similar to that of cuttings.*

1065. *Why should standard fruit trees never be planted in the kitchen garden?*

Because, from their *drip and shade*, it is *impossible to grow good culinary vegetables under them;* while, on the other hand, *the constant digging and movement of the soil* required for culinary vegetables, *make the roots of the trees*

Dictionary of Daily Wants."

"As flowers in Nature's best vermilion dyed,
The polished walks enclose on either side;
So minds with proper Cultivation drest,
Are by the warmth of Heavenly influx blest."—LAWRENCE.

descend so far, that they get beyond the influence of the air, and cannot produce *good* fruit.*

1066. *Why has man been able to establish so many varieties of fruits and flowers?*

Because *every quality in plants becomes hereditary, when the causes which first gave existence to those qualities continue to operate;* and also because *their seedling offspring have a constant tendency to adapt their habits to any climate in which art or accident places them.*

1067. This may be illustrated by the following considerations:—If two plants of the *vine*, or other tree, were placed to vegetate, during several successive seasons, in very different climates; if the one were planted on the banks of the Rhine, and the other on those of the Nile, *each would adapt its habits to the climate in which it were placed;* and if *both* were subsequently brought in early spring into a climate similar to that of Italy, *the plant which had adapted its habits to a cold climate would instantly vegetate, whilst the other would remain apparently lifeless.*†

1068. We have known *dahlias*, from a poor, single, dull-coloured flower break into superior forms and brilliant colours; we have seen a *carnation*, by the reduplication of its calyx, acquire almost the appearance of an ear of wheat, and look like a glumaceous plant; we have seen *hollyhocks* in their generations branch into a variety of colours, which are reproduced by the several descendants with tolerable certainty; we cannot, therefore, say that the order to multiply after their kind meant that the produce should be precisely similar to the original type; and if the type was allowed to reproduce itself with variation, who could pretend to say how much variation the Almighty allowed? Who can say that His glorious scheme for peopling and clothing the earth was not the creation of a certain number of original animals and vegetables, predestined by Him in their reproduction to exhibit certain *variations*, which should hereafter become *fixed characters*, as well as those variations which

* Mrs. Loudon. † T. A. Knight, Esq., F.R.S.

> "'Twas thus his fond inquiry used to trace
> Through nature's secrets with unwearied eye,
> And watch the shifting seasons' changing grace;
> Spring's first wild flower, and Summer's painted sky."—CLARE.

even now frequently arise and are nearly fixed characters, but not absolutely so, and those which are more variable, and very subject to relapse in reproduction.*

1069. *Why may great variations be produced in the flavour and appearance of fruits and vegetables?*

Because, if the *pistil* of one species be fertilized by the *pollen* of another species, which may take place in the same germs, or if two distinct varieties of the same species be in like manner intermixed, the seed which results from the operation will be intermediate between its parents, partaking of the qualities of both father and mother. In the first place the progeny is *hybrid*, or mule; in the second, it is simply *cross-bred.*

1070. The mixing of varieties by *cross-impregnation* or *bastardising* happens to a greater extent to single plants than to larger masses of them; and it seldom happens that good seed can be saved in a garden, or near gardens, from a *single individual.* Solitary specimens of the *turnip*, the *cauliflower*, and such plants, have been frequently selected on account of their perfect characters, and been carefully planted in gardens for a stock of seed; but their produce has as frequently been of the worst description, bearing no resemblance to the parent. In such cases as these, it would seem *as if bees and other insects were attracted from all quarters by the gay colours or odour, of such isolated individuals, and arriving from a hundred flowers which they had previously visited, bring with them so many sources of cross-impregnation.*†

1071. By this knowledge *we may alter the property and taste of any fruit*, by simply impregnating the one with the farina of another of the same class, as, for example, a *codlin* with a *pearmain*, which will occasion the codlin so impregnated to last a longer time than usual, and be of a sharper taste; or if the winter fruit should be fecundated with the dust of the summer kinds, they will decay before their usual time; and *it is from this accidental coupling of the*

* Dr. Herbert.

† Lindley's "Theory and Practice of Horticulture."

> "Yes, manhood's warm meridian sun
> Shall ripen what in Spring begun:
> Thus infant roses, ere they blow,
> In germinating clusters grow."—COTTON.

farina of one kind with the other that, in an orchard where there is a variety of apples, even the fruit gathered from the same tree differs in flavour and times of ripening; and, moreover, the seeds of those apples so generated being changed by that means from their natural qualities, *will produce different kinds of fruit if they are sown.**

1072. This tendency to variation by cross-impregnation was noticed by Theophrastus and Pliny; and, in 1745, Mr. B. Cook, F.R.S., communicated to the Royal Society the case of some *russets,* charged by the farina of trees, growing in the orchard of a neighbour. The charged russet grew among a great number of unaltered apples, but bore the exact complexion of the apples growing upon a neighbouring tree.†

1073. Early in the year 1820, Mr. Braddick sent to the Royal Society samples of two sorts of apples of the preceding year's growth which he had himself taken from the trees, and carefully preserved, to show the extraordinary sport which they had made. The two sorts were the *Holland pippin* and the *white winter calville,* apples totally dissimilar in appearance; they grew on low standards, very near each other; two of the specimens gathered from the sides of the trees not contiguous retained their natural character perfectly well; but the *white calville* gathered from the side of the tree next the *Holland pippin* had lost much of its own form and colour and partaken largely of that of its neighbour, while the *Holland pippin,* taken from the side next the *calville,* had become nearly a *calville* in form and colour.‡

1074. Mr. John Goss cross-impregnated some *prolific blue* and *dwarf peas,* and found that the colour of the peas, instead of being a deep *blue,* like their female parent, was of a *yellowish white,* like the *male.* Towards the end of the season he found that these white seeds had produced some pods with *all blue,* some with *all white,* and many with *both* blue and white in the same pod. In the following spring he separated all the blue peas from the white, and sowed each

* Bradley's "Improvements in Planting and Gardening."

† "Philosophical Transactions." A further proof of such intermixture taking place is given by the same writer in the "Transactions," for the year 1748-9.

‡ Mr. John Turner, "Horticultural Society's Transactions."

"He therefore, who would see his flowers disposed
Sightly, and in just order, ere he gives
The beds the trusted treasure of their seeds,
Forecasts the future whole."—COWPER.

colour in separate rows. He found that the blue produced *only blue*, while the white seeds yielded some pods with *all* white, and some with *both* blue and white intermixed.*

1075. *Why are there so many varieties of the genus brassica, or cabbage tribe?*

This interesting and valuable tribe of plants, which includes not only cabbages, but all the varieties of *brocoli*, *cauliflowers*, *turnips*, and *radishes*, are supposed to have sprung from one simple original—the wild cabbage—*brassica*, *oleracea* or *sea cabbages*, the remarkable varieties of which have been altered by the influence of various climates and modes of cultivation, as well as increased by crosses obtained from the intermixture of races and varieties.†

1076. The PARENT of all the *brassica varieties*, grows wild in many countries, especially in places adjacent to the sea. It is particularly distinguished by an herbaceous and biennial stalk, by its leaves being covered with a glaucous bloom, and glabrous from their first appearance, somewhat fleshy, not actually scolloped, but sinuating to the mid-rib, the lower leaves not excepted.

1077. The first VARIETY which sprung from the original *species* appears to have been the *wild cabbage* (*brassica oleracia sylvestris*). The stalk of the *wild cabbage* is crooked, half-woody, branching, and seemingly perennial, though it most probably runs to seed at the end of two, three, or four years, and then dies. From the remarkable thickness of the parent stalk, compared with its height, we can easily account for the thick and fleshy stalk of some of its varieties. The leaves, which shoot from the summit of the sterile branches, form a kind of *rose*, giving to the wild plant an intermediate aspect between the two leading races, the *round-headed cabbage*, and the *cavalier*,

* "Horticultural Society's Transactions."

† For an interesting account of the gradual *development of varieties* of flowers fruits, and esculent vegetables, with illustrations of their transitory stages, see the "Botanical and Horticultural Reason Why."

"I make some proper signals known to bees,
To bid their squadrons welcome to my trees;
Then at the sounding brass they all descend,
And hang in clusters at a branch's end."—LAWRENCE.

or tall cabbage, so that one may easily conceive it to have degenerated to both of these. When its natural tendency to form a rose ha been gradually decreasing, or, in other words, when the stalk or branches have had a greater tendency to shoot than the leaves, *it has produced the race of cavalier cabbages;* when on the contrary, the disposition of growing to a rose has been gaining strength, and the vigour of the stock diminishing, *the race of round-headed cabbages has been obtained.*

1078. On comparing the wild individuals, it is easy to conceive that, by culture, varieties have been obtained with leaves more or less swelled out, such as the *savoy*.

1079. A generous nutrition was found to promote the growth of the soft vegetable tissues more rapidly than that of the fibrous veins on stalks, and *from perseverance in this treatment the savoy variety arose.*

1080. The leaves of the wild cabbage are naturally green, and *become red when much exposed to the sun;* this reddish colour has become permanent in some cultivated varieties. The *flowers of the wild cabbage* are in thick bunches in the shape of a panicle; the lateral ones sprout from the axillæ of the upper leaves. These panicles form a corymb, or head, greater or less according to the distance of the lateral branches, and their length, compared to the central one, from which circumstance it is easy to imagine the gradual development until the character of the *cauliflower* becomes determined. This minute examination of the wild cabbage will enable us to understand how the many cultivated varieties may all be referred to one and the same type. The *turnip cabbages* remarkable for a swollen and fleshy stem, are intermediate between the proper *cabbages* and *turnips.*

1081. There is no doubt that many of the varieties are *the results of different cross-breeds, obtained by mere chance,* in various gardens, and *preserved by the care of the cultivator.**

1082. *Why are melons of British growth defective in richness and flavour?*

Because, in the culture of this plant, too little regard

* M. De Candolle, "Transactions of the Royal Horticultural Society."

'We track, half-hidden from the world besides,
Sweet hermit-nature that in woodlands bides;
Where nameless flowers that never meet the sun,
Like bashful modesty, the sight to shun."—CLARE.

is paid to the development of the *leaves*—organs upon which the *perfection of the fruit* materially depends.

1083. The power of each proper leaf to generate sap, in any given species and variety of plant, appears to be in the compound ratio of its width, thickness, and the exposure of its upper surface to light, in proper temperature. As the growth of the plant proceeds, the number and width of the leaves increases rapidly, in proportion to the number of young leaves to be found; and the creation consequently exceeds the expenditure of true sap. This, therefore, accumulates during a succession of weeks, or months, or years, according to the natural habits and duration of the plant, and varying considerably according to the soil and the climate in which each individual grows: and the sap thus generated is deposited in the *bulb of the tulip*, in the *tubes of the potatoe*, in the *fibrous roots of the grasses*, and in the *alburnum* (sap) *of trees*, during winter, and is dispersed through their bark, during spring and summer.

1084. As soon as the plant has attained its age and puberty, a portion of its sap is expended in the production of blossoms and fruit. The fruit or seed-vessels appears to be generated wholly by the sap of the plant, and its chief office to be that of adapting the fluid, which ascends into it, to afford proper nutriment to the seeds it contains.

1085. The leaves of the *melon*, as of every other plant, naturally arrange themselves so as to present, with the utmost advantage, their upper surfaces to the light; and if, by any means, the position of the plant is changed, the leaves, so long as they are young and vigorous, make efforts to regain their proper position. But the extended branches of the melon plant, particularly under glass, are slender and feeble; its leaves are *broad and heavy*; and its *leaf-stalks long*; so that *if the leaves be once removed, either by the weight of water from the watering-pot, the hand of the gardener in pruning, in eradicating weeds*, or any other cause, from their proper position, they NEVER AGAIN REGAIN IT; and, in consequence, a large portion of that foliage, which preceded, or was found at the same period with the blossoms, and which *nature intended to generate sap to*

"The sapless branch
Must fly before the knife; the withered leaf
Must be detached."—COWPER.

feed the fruit, becomes *diseased and sickly, before the fruit acquires maturity.**

1086. *Why is it necessary to regulate, not only the* temperature, *but the* humidity *of hot-houses?*

Captain Sabine, in his meteorological researches between the tropics, rarely found, at the hottest period of the day, so great a difference as *ten degrees,* between the *temperature of the air* and the dew-point; making the *degree of saturation* about 73°, but most frequently 5°, or 85°; and the mean saturation of the air could not have exceeded 91°. Now, if the hygrometer were consulted, it would be no uncommon thing to find in *hot-houses,* as at present managed, a difference of 20° between the point of condensation and the air, or a degree of moisture falling short of 50°.

1087. The danger of over-watering most of the plants, especially at particular periods of their growth, is in general very justly appreciated; and in consequence the earth at their roots is kept in a state comparatively dry; the only supply of moisture being commonly derived from the pots, and *the exhalations of the leaves is not enough to saturate the air:* the consequence is, *a prodigious power of evaporation.*

1088. This is injurious to the plants in *two ways:* in the first place, if the pots be at all moist, and not protected by tan or other litter, *it produces a considerable degree of cold upon their surface,* and communicates a chill to the tender fibres with which they are lined. The danger of

* T. A. Knight, Esq., F.R.S.

"The corn the greedy *reapers* cut not down
Before the fields with golden ears it crown;
Nor doth the verdant fruits the gardener pull;
But man is cropt before his years are full."—DRUMMOND.

such a chill is carefully guarded against in the case of watering, for it is one of the commonest precautions not to use any water of a temperature at all inferior to that of the hot air of the house; inattention to this point is quickly followed by disastrous consequences. *The danger is quite as great from a moist flower-pot placed in a very dry atmosphere.*

1089. The flowers of the torrid zone are many of them of a very succulent nature, largely supplied with cuticular pores; and their tender buds are unprovided with those integuments and other wonderful provisions by which nature guards her first embryo productions in more uncertain climates. Comparative speaking, they shoot naked into the world, and are suited only to that enchanting mildness of the atmosphere, for which the whole system of their organization is adapted. In the tropical climates the sap never ceases to flow, and sudden checks or accelerations of its progress are as injurious to its healthy functions as they are necessary in the plants of more variable climates to the formation of those *hybernacula* which are provided for the preservation of the shoots in the winter season. Some idea may be formed of the prodigiously increasing drain upon the functions of a plant arising from an increase of dryness in the air from the following consideration. If we suppose the amount of its perspiration, in a given time, to be 57 grains, the temperature of the air to be 75°, and the dew-point 70°, or the saturation of the air being 849°, the amount would be increased to 120 grains in the same time if the dew-point were to remain stationary, and the temperature were to rise to 80°, or in other words, if the saturation of the air were to fall.

1090. Besides this power of transpiration, the leaves of vegetables exercise also an absorbent function, which must be no less disarranged by any deficiency of moisture. Some plants derive the greatest portion of their nutriment from the vaporous atmosphere, and all are more or less dependent upon the same source. The *Nepenthes distillatoria* lays up a store of water in the cup formed at the end of its leaves, which is probably secreted from the air, and applied to the exigencies of the plant when exposed to drought, and the quantity, which is

" The stone-rock'd waggon with its rumbling sound,
The windmill's sweeping sails at distance seen;
And every form that crowds the circling round,
Where the sky stooping seems to kiss the meeting ground."—CLARE.

known to vary in the hot-house, is no doubt connected with the state of moisture of the atmosphere.*

1091. *Tropical plants require to be watered at the root with great caution,* and it is impossible that a sufficient supply of vapour can be kept up from this source alone. There can, however, be no difficulty in keeping the floor of the house, and the flues continually wet, and an atmosphere of great elasticity may thus be maintained in a way perfectly analogous to the natural process. Where steam is employed as the means of communicating heat, an occasional injection of it into the air may also be had recourse to; but this method would require much attention on the part of the superintendent, whereas the first cannot easily be carried to excess.

1092. *Why should straw be laid under strawberry plants when coming in fruit?*

Not only because it prevents the fruit from coming in contact with the soil, but because it *shades the roots from the sun;* prevents the *waste of moisture by evaporation,* and consequently, in dry times, when watering is necessary, makes a less quantity of water suffice than would be used if the sun could act immediately upon the surface of the mould.

1093. The custom of laying straw under strawberry plants, when their fruit begins to swell, is probably very old in this country: the name of the fruit bears testimony in favour of this conjecture, for the plant has no relation to the straw in any other way.†

1094. *Why do early potatoes fail to produce seeds?*

Because of the *preternaturally early formation of the tuberous root,* which *draws off for its support that portion of the sap, which in other plants of the same species, affords* nutriment to the *blossoms and seeds.* When means are

* J. F. Daniell. † Sir Joseph Banks.

But give me to ponder still
Nature, when she blooms at will,
In her kindred taste and joy
Wilderness and variety;"—CLARE.

taken to prevent the formation of tuberous roots, good seeds may be procured.*

1095. *Why are holly fences superior to hawthorn for gardens?*

Hawthorn fences are usually the resort of *small beetles, caterpillars,* &c., which, after denuding the fence of leaves, *pass to the nearest trees* and *shrubs*, and extend their depredations. The leaves of the *hawthorn* also exhale a great deal of water, rendering the air cold which passes through them.

1096. This may be accounted for on the same principle that cool air is obtained in the houses of the wealthy in the East Indies, by sprinkling branches of trees with water in their verandahs. *Hollies, laurels,* and most evergreens, exhale but little water from their leaves at any other season of the year, except for about a month in June, when their new leaves are recently expanded; consequently, in April and May, when we most require warmth, and again in September and October, the leaves of these trees, when fully exposed to the sun, become sensibly heated, and impart warmth to the air which passes through them.†

1097. *Why is it a common error among gardeners and farmers that insects, &c., are destroyed by frosts?*

The *eggs* of the *silk-worm,* and of other species, are capable of sustaining a great degree of cold; and Reaumur found that a common caterpillar was not hurt by cold of 11° below the zero of Fahrenheit. It has been found that some *caterpillars* and *larvæ,* after being so frozen as to chink like little stones when dropped into a glass, nevertheless revived. Both experiment and fact prove, that the supposed destruction of insects by severe

* T. A. Knight, F.R.S. † J. Williams, Esq.

"Ask we what makes one keep and one bestow,
That Power who bids the ocean ebb and flow;
Bids seed time, harvest, equal course maintain,
Through reconciled extremes of drought and rain."—POPE.

winters does not take place; and, consequently, that *the gardener must rely on his own exertions for ridding himself of these assailants.*

1098. But frosts are frequently the *indirect* cause of the destruction of insects, worms, and slugs, by making birds and other enemies search for them with greater diligence.

1099. *The caterpillars of the gooseberry moth may be destroyed* by laying a large sheet of strong paper on the ground, underneath the branch. Let the sheet be so laid, and a sudden shake given to the branch; nine-tenths of the caterpillars will immediately let themselves down on to the paper by a silken thread, when they may be collected with the greatest ease. By going over the trees twice or thrice in this way, the whole may be extirpated far more effectually, and at less expense both of money and time, than by watering trees with solutions of lime, tobacco, &c.*

1100. *In what way does the common earth-worm operate upon soils?*

Although one of the very humblest and most despised creatures in existence, the *common earth-worm*, or *dew-worm*, plays a very important part in the economy of the earth. As it is found almost everywhere, few persons are unacquainted with its appearance.

1101. It inhabits holes, which it makes in part by eating its way through the mould, the food it seeks being such decayed organic substances as it finds among, or drags down into it. These it takes, mixed with a certain portion—seldom, perhaps, less than a fourth, and sometimes much more—of the mineral ingredients of the soil: clay, sand, and grit; and it is surprising to see what large and sharp-edged grains of the latter it will swallow.

* W Spence, Esq.

"No floure in field that dantie odour throwes,
And deckes his branch with blossoms over all,
But there was planted or grew natural."—SPENCER.

When it has digested that portion of this strange diet which is digestible, it throws out the remainder, either upon the surface above it, or else into one of its own, or of another worm's deserted galleries, in those familiar vermicular lumps which are called *worm-casts*. The mineral and vegetable matter ejected is no doubt *a very valuable manure.*

1102. But these contemned animals have another office, less obvious, but perhaps more important. Although the casts of the larger worms are the more conspicuous, standing up as little mounds at no great distance from one another, yet they may not, perhaps, effect so much upon the whole as the smaller heaps of the greater multitude of younger worms, which are hidden under the herbage. The quality of matter thus moved is sometimes astonishing, scarcely a space of two inches square being without a little heap of cylindrical castings.

1103. As the worms desert their old burrows, the soil sinks in and fills them; and by this means, a constant circulation is continued, the vegetable mould extending itself downwards, while the "dead soil"—the purely mineral matter—is brought up.

1104. What *the plant* specially wants from the soil (as is strongly enforced in the views of Liebig), is *mineral matter;* and this *the earth-worm keeps within its reach, by continually transferring it from below upwards, in a properly comminuted state.* Every shower that falls washes away some of this valuable matter, as any one may see who will watch the rills which trickle over the surface at the time; and if the rain is heavy, it carries off a great quantity of clay and sand. The unavoidable consequence of this natural operation would be that the upper layer would consist chiefly of the coarser materials, the larger grit and stones, which would be ill adapted for the support of the more valuable kind of herbage. *But the earth-worm supplies the waste.**

1105. *Why should precautions against insects of all kinds be adopted early in the season?*

Because, when they are allowed to be *developed to*

* "Geology in the Garden."

"When to turn
The fruitful soil, and when to sow the corn;
The care of sheep, of oxen, and of kine;
And how to raise on elms the teeming vine."—DRYDEN.

maturity, they PROPAGATE BY EGGS IN SUCH ABUNDANCE, *that it is almost impossible to keep them under.* THE DESTRUCTION OF ONE EARLY MOTH IS A FAR BETTER PREVENTIVE THAN KILLING A HUNDRED CATERPILLARS.*

1106. *The mode I would recommend in the case of almost all insects* injurious to the horticulturist, is to *employ children in the summer months to destroy the moths themselves*, giving a small premium for every ten or twenty they collect, and increasing the reward as the number becomes lessened. When taught where to look for them, they would discover numbers on the bark of trees; and if provided with gauze clasp-nets, would find it a most healthy and interesting occupation to catch them when made to fly, by shaking the trees and bushes in which they repose. *The destruction of every female moth before the deposition of eggs, may be fairly calculated to prevent the existence of some hundreds of larvæ;* and thus, in any garden not in the neighbourhood of others, where the same methods are neglected, the whole race might in a few years be extirpated.†

1107. *Slugs may be effectually destroyed by lime-water*, which is greatly superior to *lime-dust*. Take some fresh caustic lime, and pour on it some hot water; when thoroughly dissolved, add water sufficient to make it pass through a fine rose of a water-pot. Previous to the preparation, let a woman take some *peas haulm* (I give that the preference), or any large leaves of the *cabbage* tribe, and lay them a pole distance from each other. If the weather permit, they will be found in abundance, collected under the haulm, &c., both for shelter and food; as we always find them prefer vegetables in a state of stagnation, to those luxuriant in growth; when properly collected, let a boy take up the haulm, &c., and, by a gentle shake, leave the whole of the slugs on the ground. The woman with a water-pot must then pour a very small portion of the liquor on them, and the boy in the mean time must remove the haulm, &c., to a different spot in the intermediate space. By pursuing this plan for one week (when the weather is favourable), I am perfectly satisfied the whole

* A great variety of information upon the habits of insects, with means for their extirpation, will be found in the "Entomological Reason Why."

† W. Spence, Esq.

of them may be destroyed, as the least drop of the liquor will cause immediate death, whereas with lime they frequently leave a slimy matter behind, and escape. In the flower-garden it will be found great acquisition, by watering the edging of box, thrift, &c.; for wherever it penetrates, it is certain to kill, even in a rainy season.*

1108. *An excellent method for destroying the red spider, scale, thrips,* and *green fly,* is the following:—Where there are but a few plants infested with either kind of insect, take a one-light frame and place the plants infested about four inches apart, and then procure from one to two gallons of green laurel leaves and well bruise them, immediately place them between the pots and close the frame with the least possible delay, taking care to keep the frame air-tight; at the expiration of one hour take out the plants infested with red spider and green fly, and it will be found that the insects cease to exist.

1109. It will take from eight to twelve hours to destroy the thrips and scales; at the expiration of that time take out the plants, place them in a warm and exposed situation, and in a few days the insects will all dry up and fall off.

1110. When plants are infested in stoves or green-houses with either insect, the process must be a little varied. A house 12 feet by 20 will require about two bushels of leaves; they can be bruised in the house, and placed in a tub or box, and covered with a sack or cloth, until a sufficient quantity is bruised; then they are to be strewed in the paths, and between the pots, and other vacant places, and the house must be kept as close as possible for at least twelve hours; the evening will be found the best time, so that the house can remain closed and covered with double mats at night. I have found, by repeated trials, that the plan thus described answers better than any I have ever used or heard of.†

1111. *The red spider may be banished from hot-houses and green-houses,* by the simple process of cutting off the infected leaf. A leaf once attacked soon decays and falls off; but then the animals *remove to another.* By carefully pursuing this amputation, plants will become remarkably healthy.‡

1112. *Insects in wood and walls may be destroyed* by washing

* Mr. J. Wilmot, F.H.S. † Mr. J. Ingram.
‡ Sir Brooke Boothby, Bart.

> "In a plain pleasant cottage, conveniently neat,
> With a mill and some meadows—a freehold estate,
> A well meaning miller by labour supplied
> Those blessings, that grandeur to great ones denied."—CUNNINGHAM.

those parts with a *solution of corrosive sublimate in water.* But *care must be taken that none falls on the plants;* and the workmen must be apprised of the strength of the POISON.*

1113. *The red spider may also be destroyed* by a wash of quick-lime, adding to it a quantity of *sulphur vivum;* with this wash, *brush over the flues of the house;* a fire rather stronger than usual should be kept up for a few days after the operation; the fumes will then be so effectual that scarcely any spiders will be found alive.†

1114. *Aphides are easily killed* by burning tobacco in a chafing-dish, provided it is done while they are in a young state; but it is expedient to *have these remedies used before the plants can be injured by the attacks of insects.*†

1115. *The scaly insect, and mealy bug,* when they are once perceptible to the eye, can be removed only by *picking off,* or *washing the leaves and branches with a sponge.*†

1116. *The black leech-like maggot on thorns, pears, and cherry trees, and the gooseberry caterpillars may be destroyed* by slacked lime in very fine powder, dusted over the leaves while they are wet, or dewy. If rain follows immediately after the dusting, the good effect will be diminished. Like all such remedies, the earlier it is applied, after the insect is discovered, the better; and it should be done *before the fruit changes colour,* lest it be disfigured. Lime water, thrown by the garden engine, is also effective; but *it renders the trees and borders unsightly. A decoction of elder-leaves mixed with soap is also effective.*‡

1117. *As a general destroyer of insects upon trees,* GAS WATER is exceedingly effective. Mix a pound of flour of brimstone in three gallons of gas water, with soap enough to make it adhere to the buds and branches when laid on with a painter's brush. The composition may be mixed over a fire with safety, as it is not inflammable, the gas water being merely that which is employed at gas-works in the purification of gas. It does no injury to the trees, and probably kills the insects by its offensive odour.§

1118. *The moths and caterpillars of the Phalæna Brumata may*

* Sir Brooke Boothby, Bart.

† W. Kent, Esq., F.L.S.

‡ Mr. John Sweet.

§ J. Braddick, Esq., F.H.S.

be destroyed in the following manner:—A mixture of oil and tar (which keeps moist longer than tar alone) to be painted in a broad ring around the trunk. This prevents the caterpillars from descending the trunk to work themselves into the bark near the root, to assume the chrysalis state. This change usually takes place between the end of October and December; in which months vast numbers of them may be seen on a mild day about the roots of the trees. When the caterpillars are located upon the branches, the latter should be well shaken. The caterpillars falling to the ground may be destroyed.*

1119. The caterpillars are about half an inch in length, and of a green colour; these are exceedingly destructive to rose-buds, and the ointment of oil and tar may therefore be advantageously employed upon the stems of rose-trees.†

1120. *The Aphis Lanigera, or American blight, may be destroyed* on trees by applying train oil, with a painter's brush, to the infected parts of the tree. No mischief will result from the application of the oil to such parts of the tree *only* as are affected by the insects.‡ In America the following remedy is successfully applied:—Before the sap leaves the root, take the earth from around the tree, at least for a foot and a half, and half a foot deep. Mix a quantity of coal soot with fresh rich mould, and fill up the hole again. Be careful to carry off the old earth, and to burn it, lest the insect should be generated in it by the heat of the sun.§ Tar, applied with a painter's brush, is also an effectual remedy, and it operates, no doubt, in the same manner as the oil, by excluding the air, and involving the insects in a mass from which they cannot escape. It is probable that the effect of the tar is more lasting than that of the oil, and that it would more completely destroy any young insects that might be produced from the latent eggs, a considerable time after their application. Tar, however, destroys the leaves and young shoots, but it does not affect the wood.‖

1121. *In applying lime for the destruction of snails*, I began by sprinkling quick-lime lightly over the beds adjoining alleys and walks about ten o'clock at night, after a wet or very dewy evening, and I usually found a large number of snails, many of them exceedingly

* Mr. Rausleben, of Berlin. † Mr. MacLeay. ‡ Sir Oswald Mosley, Bart.
§ Mr. Walton. ‖ A. Seyton, Esq., F.H.S.

"The shepherd, he was on his rounds,
The dog stopt short to lap the stream,
And jingling in the fallow grounds
The ploughman urged his reeking team."—CLARE.

small, dead on the following morning; but some always escaped, and I suspected these to be of another species, which did not leave their hiding-places so early in the evening as the others. I, therefore, tried the effect of sprinkling the lime over the same beds and walks about three o'clock in the morning; and, by these means, in a short time ceased to be troubled with snails of any kind in situations where they were before very abundant and destructive. The lime used should be fresh burned, and it should be sprinkled regularly though lightly, not only over the ground, but over every plant in the vicinity.*

1122. *The American blight on apple trees may be destroyed* by potash and quick-lime in equal quantities, mixed in water to the consistence of cream. The mixture, whilst hot, is to be laid on the stem and branches of the tree with a brush, rubbing it well into the crevices of the bark, which should be scraped and cleaned before the wash is applied. It may be used in the autumn, or during the winter, whilst the branches are destitute of leaves. It will effectually *kill the insects*, and consequently *prevent their appearance in the succeeding spring*.†

1123. *Fruit may be preserved from birds* by a somewhat singular expedient, namely, the employment of CATS. R. Brooke, Esq., of Melton Lodge, Suffolk, pursued the plan for several years with the most perfect success. He had four or five cats, each with a collar, and light chain and swivel, about a yard long, with a large iron ring at the end; as soon as the gooseberries, currants, and raspberries began to ripen, a small stake was driven into the ground, or bed, near the trees to be protected, leaving about a yard and a half of the stake above ground; the ring was slipped over the head of the stake, and the cat thus tethered in sight of the trees: no birds would approach them. Cherry trees and wall-fruit trees were protected in the same manner as they successively ripened; each cat, by way of a shed, had one of the largest-sized flower-pots, laid on its side, within reach of her chain, with a little hay or straw in bad weather, and her food and water placed near her.‡

* Mr. J. Corbett. † J. Wedgwood, Esq. ‡ P. Kendall.

"Trees old and young, sprouting, a shady boon
For simple sheep; and such are daffodils
With the green world they live in."—KEATS.

MISCELLANEOUS.

1124. *What are the relative nutritive qualities of the chief vegetables used as food?*

The nutritiveness of any kind of solid or liquid food depends upon three circumstances:—its digestibility, the quantity, and the proportions of the alimentary substances contained in it.

1125. If an aliment contains many indigestible substances, which are voided again in an undissolved state with the excrements, it must lose as much of its nutritiveness: for only that which passes as an essential constituent into the blood, is to be considered as an alimentary principle. The more digestible an aliment is, therefore, other things being equal, the more nourishing.

1126. In treating of the value of a nutriment with respect to the alimentary principles contained in it, no regard is paid to the amount of water contained. Water is, in general, so easily to be procured, that we have not to take it into consideration, when judging of the value of solid or liquid food, with respect to its nutritious qualities. *In a dry arid desert, however, water would become the most important nutriment; and an aliment containing much water would be the most nutritious food.* Where no deficiency in water exists, that aliment is the most nutritious which contains the greatest proportion of alimentary principles, and conveys, therefore, to the blood, the greatest quantity of its essential constituents.*

* Dr. Scoffern: Orr's "Circle of the Sciences."

"Or meeting objects from the rousing farm;
The jingling plough-teams driving down the steep,
Waggon and cart—and shepherd-dog's alarm,
Raising the bleatings of unfolding sheep."—CLARE.

1127. The dependence of the nutritive qualities of various articles of food upon the proportion of nitrogen is well shown in a recent Memoir of Monsieur Boussingault, who gives, on the authority of the celebrated agriculturist Von Shaer, a scale of the relative degree of nutriment afforded by various plants to cattle, and then places by the side of it a statement of the proportion of azote present in them from which it appears that the nutritious quality of each bears a pretty constant ratio to the quantity of nitrogen they contain.

1128. This may be seen by the following table:—

	Nutriment Equiv.		
Ordinary Hay	100	its azote being	0·0118
Red Clover	90	"	0·0176
Beans	83	"	0·0141
Wheat Straw	400	"	0·0020
Potatoes	200	"	0·0037
Beet	397	"	0·0026
Maize	59	"	0·0164
Barley	54	"	0·0176
Wheat	27	"	0·0213

1129. When we reflect, indeed, that animal matter, which so abounds in nitrogen, is nevertheless derived, either directly or indirectly, from vegetable, it follows, as a necessary consequence, that existence can only be maintained by the aid of those principles in plants which contain a certain proportion of the element alluded to. And this has been shown by the experiments of Magendie upon dogs which were fed on sugar, starch, gum, and other substances destitute of nitrogen, and in a very short time pined away and died.*

1130. *What relation subsists between the elementary composition of vegetables and of animal flesh?*

The flesh of oxen, or beef, illustrates the composition of all other kinds of meat. *We may take the composition of beef as the standard,* with which the varieties of the other most common aliments may be compared. In beef, as in

* Dr. Daubeny.

"While the cock with lively din,
Scatters the rear of darkness thin,
And to the stack, or the barn-door,
Stoutly struts his dames before."—MILTON.

all other aliments which, when taken to the exclusion of all other food; are able to maintain human life, the three groups of simple elementary principles are represented. These groups are :—1. The inorganic. 2. The organic destitute of nitrogen. 3. The organic possessing nitrogen A combination of albuminous and fatty matters, of compounds of chlorine and of salts, abundantly diluted with water, is all that is necessary to sustain life.

1131. The albuminous substances of beef are the fibrine, or flesh fibres of the muscle and albumen, which is the essential body of the nutritious juice which occupies the space between the solid parts. The white of a hen's egg (albumen) gave its name to what are called albuminous substances. The flesh owes its red colour to the blood, which it contains in very numerous vessels ; and this blood contains both albumen and fibrine, and in addition to these albuminous substances, some other organic matters in small quantity, besides colouring matter containing iron.*

1132. All kinds of corn, including rice, maize, oats, barley, rye and wheat, contain in their seeds a large quantity of undissolved vegetable albumen, combined with a little vegetable gelatine. The latter compound belonging, like the former, to the albumenous matters, is a glutinous substance, which communicates its property to the whole combination; from this circumstance it is called *gluten*. In addition to the gluten most kinds of corn contain a small quantity of soluble vegetable albumen.

1133. The constituents of fat are also abundantly represented in all kinds of flour; for all kinds of corn contain a quantity of starch so considerable, as by far to surpass their amount of albuminous substances. Besides the starch, a proportion of gum is always present Finally, all the inorganic constituents of the human body, are present, with the organic, in the seeds of the cereals, namely, soda and potash,

* Dr. Scoffern.

"The gaudy tulip, that displays
Her spreading foliage to the gaze;
That points her charms at all she sees,
And yields to every wanton breeze."—E. Moore.

magnesia and lime, iron and chlorine, phosphorus and sulphuric acids, &c. The phosphates of the alkalies and earths, predominate amongst the salts, and magnesia among the earths.*

1134. Wheat contains the greatest quantity of gluten, and the smallest of starch; rye a medium proportion of both; while in rice and barley, in oats and maize, the largest proportion of starch, and the smallest of gluten, are to be found. Maize is remarkable for its considerable proportion of fattening matter. In the external covering of all kinds of grain there are contained much more gluten and fat than in the interior. Peeled rice and pearled barley have, therefore, lost a great deal of their nutritiveness; and bread containing the bran is much more nourishing than that prepared from sifted flour; but the power is rendered, by the hard cellular tissue which it contains, much more difficult of digestion than the latter.*

1135. *Why is the system of "chaff cutting" beneficial?*

Because the food is more *easily and perfectly masticated;* but *chiefly* because it *prevents waste,* and admits of *different qualities*—as of *hay* and *straw,* or *straw* and *green forage*—being so mixed that animals cannot *pick out the one from amongst the other,* but must eat the mixture as it is presented to them. Such cut fodder also forms an excellent vehicle in which to give *meal* or *bruised grain,* either cooked or raw, to live stock.†

1136. *Why is green clover better food than the hay that is made for it?*

Because, in the process of drying, many of its vegetable particles are so hardened that the digestive organs have no longer any power to act upon them.‡

1137. *Why does steaming clover-hay improve its feeding qualities?*

Because it softens the hardened particles, and, conse-

* Dr. Scoffern. † Encyclopædia Britannica. ‡ Dr. Spregnel.

> "As from each barn the lumping flail rebounds
> In mingling concert with the rural sounds;
> While o'er the distant fields more faintly creep
> The murmuring bleatings of unfolding sheep."—CLARE.

quently, there is a less quantity of such food required than of the dry.*

1138. It has always been an agreeable thought to me, that the improvement of farming *tends greatly to increase the comfort of all the animals usually found* on a farm. Under the old system there was, and still is, where it lingers, a great deal of *unreflecting cruelty*. The sheep, when kept for wool only, is even yet, on some of our moorlands, left to its fate in the winter, and not uncommonly *dies of starvation*. By the improved system, *the farmer is taught to keep his animals in a thriving state steadily from their birth*. Even horses, though not meant to be eaten, should not be stinted of food. Railway contractors hardly measure their horses' oats, and two well-fed horses can do as much work or more, for the same provender, which, on the old system, *enabled three horses barely to crawl*. We have now learnt that *for our own* interest, every animal on a farm should live well, and that a hard steck-master is a bad farmer.†

1139. *Why should not calves be fed exclusively or chiefly upon turnip tops?*

Because tops in their cleanest state are apt to produce *looseness in the bowels*, partly from the sudden change of food from grass to a very succulent vegetable, and partly from the dirty, wetted, or frosty state in which they are usually given to beasts.

1140. Many farmers entertain the idea that tops make good feeding for young beasts or calves at the beginning of the season—not from the knowledge that the tops contain a larger proportion of bone-producing matter than the bulbs, as chemical analysis shows, but from a desire to keep the turnips for the larger beasts, and to rear the young ones in any way; but the notion is a mistaken one, as may easily be proved by giving one lot of calves turnip-tops and another lot bulbs without tops, when the latter will present a superiority in a short time, both in bone and flesh. No doubt the large quantity of watery juice the tops contain makes the young cattle devour them with eagerness on coming off a bare pasture, and indeed any cattle

* Dr. Spregnel. † Mr. Pusey.

"Indulged through every field by turns to range,
And taste them all in one continual change,
For though luxuriant their grassy food,
Sheep long confined but loathe the present good."—BLOOMFIELD.

will eat the tops before the turnips, when both are presented together; but observation and experience confirms me in the opinion that the time of cattle in consuming turnip-tops is worse than thrown away. *The looseness never fails to bring down their condition in so considerable a degree* that part of the *winter passes away before they entirely recover.* A *few* tops may be given to young cattle *along with straw.* The tops are not thrown away when spread upon the ground, as they serve to manure it. *Sheep* are not so easily injured by them as cattle, *on account of their costive habit.**

1141. *Improvement of sheep feeding.*—The increased use of artificial manures and bought food—the general introduction of the turnip cutter—a greater economy of straw, and its conversion into rich dung—will gradually *change the present system of breeding sheep into that of feeding out their produce also,* thereby increasing the annual return from stock, and, by the consumption of better food, adding fertility to the corn land. *Folding,* as a system, will probably be superseded by *attention being devoted to the feeding of the flock as the* PRINCIPAL *object, the* ENRICHING OF THE LAND *following as a matter of course,* but not forming, as heretofore, an object *paramount to the welfare of the stock.* It may, then, be found that *to enrich the soil by wasting the substance and injuring the constitution of the sheep in driving them to and fro, and confining them in a crowded fold,* is a *more expensive* and *less effectual* plan than *the direct application of those manures and food, which science and commerce have placed within the reach of the modern farmer.*†

1142. *What are the causes of shyness in horses?*

Shyness is often the result of *cowardice, playfulness,* or *want of work*; but it is at other times, and frequently, the consequence of *defective sight.*‡

1143. *Punishment by blows will very seldom cure vicious habits originating in fear.* All startings and fears are only increased by them, for the horse in these cases,

* H. Stephen's "Book of the Farm." † Caird's "English Agriculture."
‡ Youatt "On the Horse."

associates the dread of TWO EVILS *instead of* ONE: the consequence of which is, that *his resistance is doubled.**

1144. *What is the cause of "roaring" in horses?*

It arises from a disproportion between the size of the horse's chest, and the passages which convey air thereto. So that when the animal is pressed by exercise to breathe rapidly, the air, rushing violently through a tube of too small proportions, makes a loud grunting sound. The obstruction, either local or general, in the respiratory canal, may exist in the *larynx,* the cartilaginous box occupied by the mechanism of the voice, or it may be in the *windpipe* lower down.

1145. *The system of tight-reining is, in many cases, a cause of roaring.* It forces the lower jaw on the neck; the larynx, and the portion of the windpipe immediately beneath it, become flattened, and the respiratory passage not only obstructed, but in a manner closed. The mischief is usually done when the horse is young. It is effected in some measure by the impatience of the animal, unused to control, and suffering pain. In the violent tossing of his head he bruises the larynx, and produces inflammation. The injury is materially increased if the head is not naturally well set on, or the neck is thick, or the jaws narrow.†

1146. *Why is the condition of the base of the horn frequently indicative of the state of health of the animal?*

Because the base rests upon a bone full of *blood-vessels,* from which the horn grows. At the junction, the horn is *very thin;* and, resting upon so vascular a part as the "flint," as the bone is called, the state of the blood is easily ascertained by examining it; when the horn feels *cold,* it indicates congestion in some particular part, consequent upon inflammation.

* Blaine's "Rural Sports." † Youatt.

> "And now, in lowing train,
> Were seen slow-pacing westward o'er the vale
> The milky mothers, foot pursuing foot,
> And nodding as they move."—MALLET.

1147. *Why have some animals varied less than others under domestication?*

It is probable that some animals have a less degree of *tendency to variation than others.* But the rarity or absence of distinct breeds of the *cat*, the *donkey*, the *peacock*, *goose*, &c., may be attributed in main part to selection not having been brought into play: in cats, from the *difficulty in pairing them;* in donkeys, from *only a few being kept* by poor people, and little attention paid to their breeding; in peacocks, from *not being very easily reared*, and a *large stock not kept;* in geese, from *being valuable only for two purposes*, food and feathers, and more especially from no pleasure having been felt in the display of distinct breeds.

1148. In the domestic duck, the bones of the wing weigh less, and the bones of the leg more, in proportion to the whole skeleton, than do the same bodies in the wild duck; and I presume that this change may be safely attributed to the domestic duck flying much less, and walking more, than its wild parent. The great and inherited *development of the udders in cows and goats* in countries *where they are habitually milked*, in comparison with the state of these organs in other countries, is another instance of the effect of use. Not a single domestic animal can be named which has not in some country *drooping ears;* and the view suggested by some authors, that the drooping is due to the disuse of the muscles of the ear, from the animals not being much alarmed by danger, seems probable.*

1149. When we compare the *dray-horse* and the *race-horse*, the *dromedary* and the *camel*, the various breeds of *sheep* fitted for either cultivated land or mountain pasture, with the wool of one breed good for one purpose, and that of another breed good for another purpose; when we compare the many breeds of *dogs*, each good for man in very different ways; when we compare the *game-cock*, so pertinacious in battle, with other breeds so little quarrelsome, with "everlasting layers" which never desire to sit, and with the bantam, so small

* Darwin's "Origin of Species."

"Again the bustling maiden seeks
  Her cleanly pail, and eager now,
Rivals the morn with rosy cheeks,
  And hastens off to milk her cow."—CLARE.

and elegant; when we compare the host of agricultural, culinary, orchard, and flower-garden races of *plants*, most useful to man at different seasons of the year, and for different purposes, or so beautiful in his eyes, we must, I think, look further than to mere variability. We cannot suppose that all the breeds were suddenly produced as perfect and as useful as we now see them; indeed, in several cases, we know that this has not been their history. The key is man's power of accumulative selection: nature gives successive variations; man adds them up in certain directions useful to him. In this sense, he *may be said to make for himself useful breeds.**

1150. It is a very surprising fact that characters should reappear after having been lost for many, perhaps for hundreds of generations. But when a breed has been crossed only once by some other breed, the offspring occasionally show a tendency to revert in character to the foreign breed for many generations—some say, for a dozen, or even a score of generations. After twelve generations, the proportion of blood, to use a common expression, of any one ancestor, is only 1 in 2048; and yet, as we see, it is generally believed that a tendency to reversion is retained by this very small proportion of foreign blood. In a breed which has not been crossed, but in which *both* parents have lost some character which their progenitor possessed, the tendency, whether strong or weak, to reproduce the lost character might be, for all that we can see to the contrary, transmitted for almost any number of generations.*

1151. A pigeon fancier is struck by a bird having a slightly shorter beak; another fancier is struck by a pigeon having a rather longer beak; and on the acknowledged principle that "fanciers do not and will not admire a medium standard, but like extremes," they both go on (as has actually occurred with tumbler pigeons), choosing and breeding from birds with longer and longer beaks, or with shorter and shorter beaks.

1152. Again, we may suppose that at an earlier period one man preferred swifter horses; another stronger and more bulky horses. The early differences would be very slight; in the course of time, from the continued selection of swifter horses by some breeders, and of stronger ones by others, the differences would become greater,

* Darwin.

"Here might a sinner humbly kneel and pray,
With this bright sky, this lovely scene in view,
And worship Him who guardeth us alway!—
Who hung these lands with green, this sky with blue."—T. MILLER.

and would be noted as forming two sub-breeds; finally, after the lapse of centuries, the sub-breeds would become converted into two well-established and distinct breeds. As the differences solely become greater, the inferior animals with intermediate characters, being neither very swift nor very strong, will have been neglected, and will have tended to disappear.*

1153. Not in one case out of a hundred can we pretend to assign any reason why this or that part differs, more or less, from the same part in the parents. But whenever we have the means of instituting a comparison, the same laws appear to have acted in producing the lesser differences between varieties of the same species, and the greater differences between species of the same genus. The external conditions of life, as climate, food, &c., seem to have induced some slight modifications. *Habit* in producing constitutional differences, and *use* in strengthening, and *disuse* in weakening and diminishing organs, seem to have been more potent in their effects. * * When one part is largely developed, perhaps it tends to draw nourishment from the adjoining parts. * * Whatever the cause may be of each slight difference in the offspring from their parents—and a cause for each must exist—it is the *steady accumulation* of such differences, when beneficial to the individual, which gives rise to all the more important modifications of structure.*

* Darwin.

THE END.

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